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All communications should be addressed to the Editor.

No. 84. OCTOBER—DECEMBER, 1917. VOL. XXI.

Notices of the Aëronautical Society of Great Britain.

Obituary.

The Council regret to record the death on active service of Mr. Harold Pither, previously reported missing, who is now known to have died as a prisoner of war on July 6th, 1916. Mr. Pither had been a member of the Society since 1909.

New Members.

Fellows: F. Handley Page, A.F.Aë.S., L. Bairstow, F.R.S., A.F.Aë.S.

Associate Fellows: H. Midgley, C. R. Taylor, W. J. Taylor, C. C. Turner, E. L. Pickles, F. W. Vernon, S. J. Waters, G. S. Wilkinson, A. C. Pratt, Miss E. M. L. Keary, Capt. N. C. Spratt.

Members: F. J. Camm, E. Fairbrother, E. Sparshott, R. F. Power, H. G. Allen, A. J. Holmes, Mrs. Mary Busk.

Associate Members: C. F. Campbell, P. Sidney, G. P. Stride, G. W. Pickett, J. B. Butler, G. Budden, Mrs. E. Macalister.

Students: J. Kenyon, S. Humphries, B. W. O. Townshend, F. W. Dowd, A. H. Everitt.

Foreign Members: Franco Tosi.

Honorary Fellowship.

The Hon. Fellowship of the Society has been bestowed on Lieut.-Gen. Sir David Henderson, K.C.B., D.S.O., A.F.Aë.S.

"The Aëronautical Journal."

It has been decided that for the future this journal shall appear monthly instead of quarterly as heretofore. The price per copy will be 2s. 6d.; yearly subscription, 30s. The first issue will appear on January 15th, 1917. As a

quarterly the "Journal" has run for just twenty years. It succeeded the "Aëronautical Reports," published by this Society from 1866 to 1897.

Abstracts.

It has been decided to issue at as early a date as possible a regular series of abstracts from the Aëronautical Press throughout the world. A large number of members, adequately qualified for the work, have volunteered for this work, and it is hoped that the first instalment will be issued after Christmas in the form of a supplement to the "Journal."

Engineering Training.

A joint conference of bodies interested in Engineering Training, called together on the initiative of Mr. A. E. Berriman, was held at the Institution of Civil Engineers on October 25th. Dr. R. Mullineux Walmsley and Mr. B. G. Cooper were present as the representatives of this Society.

Appointments.

Owing to the resignation of Mr. Griffith Brewer, Mr. A. E. Berriman has been invited to act as one of the representatives of the Society on the Joint Standing Committee of this Society of British Aircraft Constructors. Lieut.-Col. O'Gorman, C.B., and Comdr. Briggs, R.N., have been appointed as representatives of this Society on the Aviation Section of the Engineering Standards Committee.

List of Members.

A new list of members is in the press. Owing to the time that has elapsed since the last list was issued, it is feared that many errors may have been included. While expressing his regret for any inaccuracies, the Secretary will be obliged if the members concerned will kindly forward him their corrections at an early date.

"COMMERCIAL AERONAUTICS."

BY G. HOLT THOMAS.

The subject I have to deal with in this paper is enormous, and of vital importance to the Empire, but it is only possible to touch very lightly on the possibilities of commercial aeronautics in the time allowed this evening. My opinion is that it will revolutionise the world not only from a commercial point of view, but from a humanitarian point, much more indeed than it has revolutionised warfare, although the effect on that is very great.

Civil, as opposed to military, aviation in pre-war days has simply meant civilian pilots acting professionally or for sporting purposes, but civil aviation after the war will certainly be of quite a different character and with objects of very much greater importance. I am not one of those who think that commercial aeronautics are going to beat railways and other forms of transport out of existence, but rather that flying will act as an adjunct to the present modes of transport.

The question which we have to decide to-night is: "Can the aeroplane, taking into account the advantages of speed, etc., which it alone possesses, be regarded as a practical means of transport?"

I wish to make it quite clear that I in no way intend to deal with the *type* of aircraft to be used for commercial purposes, but simply to deal with these uses as I foresee them in the near future.

Again, I am only, for commercial purposes, going to talk about aeroplanes. The lighter-than-air machines have their uses, but the cost is, I think, too great to bring them in for commercial purposes, at any rate at the moment (although I speak as one interested in airships as well as aeroplanes), and their speed is not sufficient. It is, however, certain that we must be first in airships, as in everything else, in this country, and airship services subsidised by the Government to a very large extent will undoubtedly be the course so far as lighter-than-air machines are concerned.

A great compliment has been paid to the Aëronautical Society and myself this evening inasmuch as we have as Chairman Lord Cowdray, the President of the Air Board, and personally I am quite as pleased to have him as my Chairman in his unofficial position, viz., as one of the most eminent business men of this country for this reason.

The successful use of aircraft for commercial purposes will depend on the views of business men, and no one is more capable than our Chairman to-night to decide whether there is a commercial use for aircraft or not, whether aerial services will constitute a financial success or not, and generally to decide whether I am talking common sense to you this evening or whether I am to be regarded, as I have been for so long, as simply an enthusiast.

In my opinion there exists no doubt at all on the matter, no more doubt than has been the case for the use of aircraft for military purposes, now proved up to the hilt; and as I was a true prophet on military uses, I would ask you to have some confidence in my statement as to commercial uses.

The history of aviation in this country is lamentable, but glorious. No country has had the practical results of flying put under its very nose more than Great Britain. The first great meeting after Rheims was held at Blackpool. In 1909 I brought Paulhan to London. In 1910 the first great town-to-town flight

in the world, London—Manchester, for which a prize of £10,000 was given by the "Daily Mail," took place. The Circuit of Britain was an event which ought to have convinced anyone. The airmen in the Circuit of Europe, after passing through France, Holland and Belgium, arrived in London to meet more police than public. The first flight on Salisbury Plain, at the Military Manœuvres in 1910, would have convinced anyone but a Britisher. But luckily, like Britishers always do, we got there in the end. Now this is all ancient history, but why I refer to it is because our want of initiative was due to public apathy and apathy on the part of business men. No country depends more on public opinion than our own. It can carry anything, and our dilatory methods in military aviation are entirely due to public apathy. The fact that a handful of machines crossed the Channel on the outbreak of war is not due to the Flying Corps. No keener body of men existed, but up to the outbreak of war they were starved. It is a wonder their enthusiasm was not entirely quenched. It was not due entirely to the War Office or the Cabinet, who, I again affirm, could do very little without public opinion behind them. The glorious record of the Flying Corps, notwithstanding their infinitesimal beginning, is now known to us all. The importance of military aeronautics is now known to us all, but nobody can say how we might have changed this war if we had taken it in time. To-night I am speaking in exactly the same strain on *commercial* aeronautics as I spoke seven years ago on *military* aeronautics, and I assert without the slightest fear that I am speaking on as large a subject, and one of just as vital importance to the Empire. But we must not let history recur. We *must* be first. No one will be quicker than the Huns to recognise the importance of this, the latest form of transport, but *this* time *we* must be the leaders. As British military aviation has shown, we have the men, second to none; we have the designs, and I am addressing you to-night to ask you to give the public support, the energy, the finance, and the encouragement which must be behind a movement of the kind if it is to succeed. It is a world-movement, and we *must* lead.

Another point is the fact that Lord Cowdray has recently appointed a Committee, with Lord Northcliffe, who has always taken such a keen interest in the subject, as Chairman, to advise on the uses and development of commercial aircraft. This Committee should be one of enormous importance, as although I shall touch to-night on a few evident uses of aviation for commercial purposes, frankly I think they are illimitable. The aeroplane is mobile. It can move from one route to another at will, and always at enormous speed compared with other forms of transit. It is going to open up the world as no other means of transport has yet done, and I look to Lord Northcliffe, whose enterprise and energy we know, to so guide his Committee that a start at any rate will be made quickly and on the right lines. Only a few days ago General Smuts said in a speech :—

> "Our Empire, peculiarly situated, scattered over the whole world, was dependent for its very existence on world-wide communications which must be maintained, or that Empire would go to pieces."

In reading a paper on "The Commercial Use of Aircraft in the Future," I am placed in a somewhat awkward position, as I have spent a good many hours explaining to the gentleman at the Ministry of Munitions who is responsible for the taxation of aircraft accounts that there is no future whatever for aircraft after the war; and this evening I am here to prove exactly the opposite. The position, however, is not so awkward as it might appear, as this paper is largely an effort of imagination, and the ideas which I have to put before you would be quite impossible to carry out unless the accounts of the aircraft companies are very liberally treated as regards their so-called profits during the war and subsidies for aerial services after the war.

I say "so-called profits" as the capital expenditure since the war in the case of aircraft companies has been so huge, and of such an extraordinary nature;

their pre-war standard is so absurd compared with other industries that taxation can with the greatest ease entirely prevent any schemes for the use of aircraft after the war by leaving no funds for development.

To carry out commercial schemes very large expenditure will be required, and this is naturally impossible unless there are funds to draw on. For commercial aircraft new types of machines will have to be devised and new problems will have to be faced.

But there is another problem for the Government in addition, viz., the question of Government subsidies for mail and passenger services.

The British Mercantile Marine has been assisted in the past by subsidy, and I fail to see why the British Commercial Air Services should not come under the same category. We know during the war how important the Mercantile Marine has been, and the Commercial Air Services, if they had been in existence and properly developed, would have been equally important, and certainly will be in the future. You can decide what we could do to-day if we had a real surplus of aircraft and pilots as well as I can. You can decide what effect on the war at the beginning we could have had with a large aerial fleet.

Aviation has suffered in the past from mere discouragement, and the people in this country must see that in the future not only is it not discouraged, but on the contrary that it is very fully encouraged.

One way of encouragement is a subsidy for passenger and mail services, and although I cannot say exactly how this could be done, I think I may safely say that all that is asked for is encouragement on business lines in the form of money paid for services rendered. But there are many doubters even in the aircraft world. Fog is mentioned, weather is referred to, and many objections raised. Several friends have said we cannot compete with trains and lorries and other forms of transport, and that we cannot carry heavy weights. One man said we could not transport a motor-car, for instance, and so on.

Now all these doubters, even if they were right, in my opinion have not altered the case one jot. They have simply done what the Army Council did when, years ago, I used to attack them daily—they have simply advanced arguments as to what aircraft will *not* do, ignoring what it *will* do. One might as well say nowadays a motor-car is no use for commercial purposes because it cannot fly. At the same time I may say that if anyone wants it it is perfectly easy to produce an aeroplane which will transport a motor-car with ease, and several machines are in existence to-day which will do it, so far as weight is concerned.

Fog, for instance, is a drawback, but it holds up trains, motor-cars, and ships. If bad enough, it stops the whole of the street traffic of this Metropolis, and personally in this new science of flying and new method of transport I would far rather accept the argument that we shall have, sooner or later, fog-penetrating searchlights on our machines, or other devices, than that fog will prevent the use of commercial aircraft.

Because we *can't* do what a train or motor-car can is no argument whatever in my opinion. The whole and only point in my case for commercial aircraft is that we *can go faster* and within certain limits carry a given weight faster than any other form of transport.

The question naturally arises as to in what way will aircraft be used commercially after the war. As I have said for nearly ten years, to prophesy for such a new science as flying is almost impossible, but many instances will crop up for the use of commercial aeroplanes, of which I may give you a few.

Surveying, for instance. I am told by my friends amongst the large contractors that it would be worth an enormous sum to be in a position not to know where to go, but to know where *not* to go; and the production of some sort of

cinematograph machine for the purpose has already been tried and certainly will be produced.

For those in a hurry. Nothing can compete with the aeroplane for those on special services in need of the greatest speed possible. This alone opens a very wide field indeed.

From a business point of view it must be remembered that speed is everything. One saw this in pre-war days in the competition between the Steamship Companies in the race across the Atlantic. A special aeroplane, *i.e.*, special used in the sense of special train, which is perfectly feasible to-day, will enable the business man to leave London in the morning, do his business in Paris, and be home again to dinner. It will take him to Bagdad in a day and a half or New York in two days. Many business men would smile at the idea of using this mode of conveyance to-day, but the only thing is to remind them that they also smiled in the early days of motor-cars, and yet half the business to-day would take double the time to do if the motor-car were not in existence.

There again many special openings will occur, and I will give you one which I discussed before the war with the Editor of the "Daily Mirror," viz., as to whether we should not keep a machine and pilot always at their disposal, in order that in the case of any such event as a big railway accident or any event of great public interest their representative should be on the spot as soon as possible, and, of course, ahead of any other paper.

A parson in a far-off Colony has already proposed to use a seaplane to fly round the coast, across bays, etc., and so visit his parish in hours instead of months of tedious travel.

Rivers again suggest a very probable and certainly useful employment of aeronautics, using them as a line of flight. Huge districts in many localities, such as Africa, are controlled by officials who usually employ the river as a means of transit, using motor launches, and then inland from the nearest point. Think of replacing this by the use of seaplanes doing 100 miles an hour. This equally applies to mails. South America, Canada, Asia, all come into this scheme, and no landing ground is required. Nature has supplied it in the form of a smooth-surfaced river. Again, these ready-made roads could be followed at night with a searchlight on the machine with the greatest ease and no danger.

The Cape to Cairo Railway again affords simply an instance which occurs over and over again in that and other countries, where an aerial service might be employed as an adjunct to the railway. The present method would probably be one's arrival at a wayside station and then, say, 50 miles in a bullock wagon, or perhaps walking, over jolty roads, or no roads at all, taking one or several days. Compare this with stepping into an aeroplane and arriving in half an hour. Certainly the development of all the Overseas Dominions will be largely affected by flying.

In this paper, however, I propose to deal with what I am sure most of you have in your minds, although there are certainly other uses, viz., the conveyance of passengers, mails, and goods to all parts of the world at a speed beyond anything yet attempted.

Now I might be asked why I have confidence in such a means of conveyance and in its success as a commercial proposition. The reasons are these:—

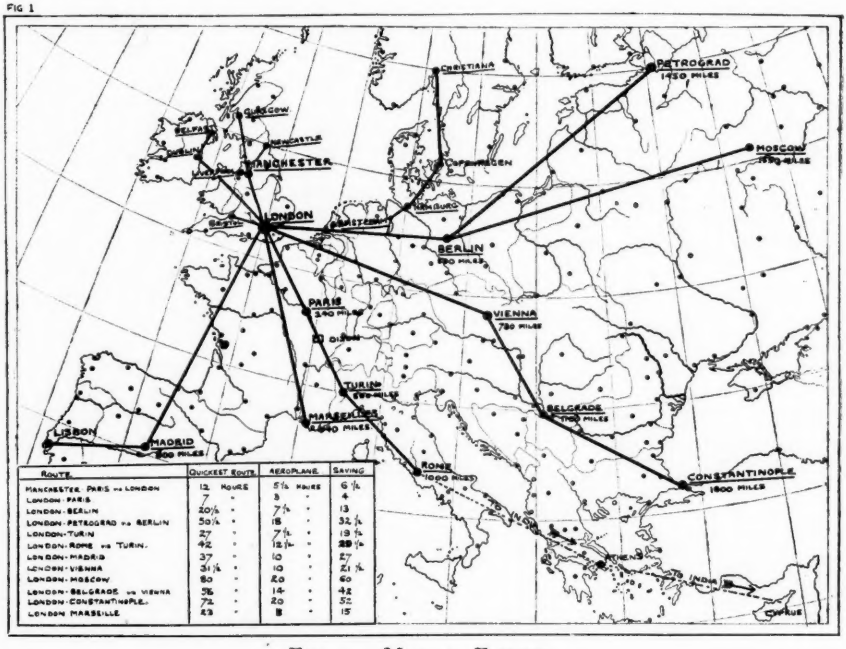
Firstly, that it is faster than any other means of transport.
Secondly, that I consider it safe.
Thirdly, that it is not too costly to provide a commercial proposition.

The first claim which I make for the use of aircraft after the war is the fact that it is the fastest form of transport in the world. We have to-day practical machines which will do well over 100 miles an hour, indeed far higher speeds, and by practical machines I mean a machine which has high speed, low landing

speed, and weight-carrying capacity, going from point to point as the crow flies, and no other mode of transit can do this. And I think our Chairman will agree with me when I say that any means of transport which can undoubtedly claim to be faster than any existing means must have a commercial future, unless it is so dangerous that it cannot be used or it costs so much that it is outside practical politics, which I will come to later.

Now as to being the fastest mode of transport, I will show you a map of Europe, with the distance to certain well-known cities defined, and compare them with the fastest times known by pre-war routes compared with reaching them by aeroplane, and you cannot but agree that whatever the disadvantages an aeroplane has, or more properly you *think* it has, it outdistances with the greatest facility any other mode of transport.

FIG 1



ROUTE.	QUICKEST ROUTE	AEROPLANE.	SAVING
MANCHESTER. PARIS vid LONDON	12 HOURS	5½ HOURS	6½
LONDON-PARIS	7 "	3 "	4
LONDON-BERLIN	20½ "	7½ "	13
LONDON-PETROGRAD vid BERLIN	50¼ "	18 "	32¼
LONDON-TURIN	27 "	7½ "	19½
LONDON-ROME vid TURIN.	42 "	12½ "	29½
LONDON-MADRID	37 "	10 "	27
LONDON-VIENNA	31½ "	10 "	21½
LONDON-MOSCOW	80 "	20 "	60
LONDON-BELGRADE vid VIENNA	58 "	16 "	42
LONDON-CONSTANTINOPLE.	72 "	20 "	52
LONDON MARSEILLE	23 "	8 "	15

FIG. 1. MAP OF EUROPE.

If you will look at the map of Europe presented on the screen you will see that Paris is brought within three hours of London instead of seven, that Rome means 12½ hours instead of 42 hours, and that Petrograd and Constantinople are both brought within a day's journey, and other instances of fast travelling. This map should be sufficient evidence, I think, to fully prove my contention that the aeroplane outdistances any other mode of transport with the greatest ease. The figures I am showing you are not guesswork and are not exaggerated, as the speed at which I have taken the machines is a speed easily attained to-day, viz., 80 miles per hour, and will certainly be increased in the future. The safe arrivals of these long-distance flights will depend largely on the question of landing grounds, to which I will come later.

Now as to the second point, safety.

Flying, even from the first, has never been really dangerous, although it has been thought so in the minds of the general public.

We are in a position to-day to decide this—at least, those who are in close touch with flying. One takes risks in many ways, but the question as to whether these risks constitute a danger concerns the percentage of accidents. One takes risks, for instance, in using a lift, and the question as to whether a lift is dangerous or not is merely one of how many people are injured or killed in using lifts. We are presumably taking risks this evening from Zeppelin raids. One takes risks in crossing the street, and in every case a decision as to whether a thing is dangerous or not is one of statistics. In flying, if statistics were taken, for instance, of the number of miles flown per accident, of the number of accidents at any aerodrome per annum, and so on, it would be found that although it is evident one is taking risks in the air, these risks do not constitute a danger. For instance, we all know that the Hendon Aerodrome has been established since 1910, and we know the number of accidents that have taken place there. This certainly would not constitute flying at Hendon as a danger, but even then from these risks of flying one must deduct such points, for instance, as dangerous machines, of which there were many in the early days; one must deduct the acrobacies which many pilots perform; but even without those deductions most people in this room know that the odds against an accident in getting into a machine and flying anywhere you like are very large. To-day most flying is war flying with war risks. It must, again, be remembered that flying is very young, and if one puts it on the same plane as motoring in the early days, motoring would be criticised as highly dangerous. Much of the flying in pre-war days has been in competitions, and one can recollect the enormous number of fatal accidents in the early motor-car races.

It is, of course, difficult to obtain exact statistics of the number of miles flown, etc., but I think I may be regarded as possessing a fairly long practical experience of flying and more or less common sense, and, frankly, I should never have flown if I had thought for one moment that I was going to be killed. I have always regarded it as very long odds that I should *not,* and even in those days the risks taken were considerably more than they are to-day.

I am dilating a good deal on safety, as I think it would be a very small future for aircraft after the war if it were looked on as highly dangerous, and the public must be instructed by practical demonstration (which means aerial services which run day after day) that flying is a good deal more practical than it looks. On this point of safety also the question of landing grounds is of immense importance, and I will show you later on why this is so.

And now for the third point, viz., the cost of running an aerial service. I think it would astonish a great many people if I could prove that the running costs of an aeroplane are not more than those of a motor-car, and I am going to quote from a chapter in a book entitled "Flying," by Hamel and Turner, to which I contributed several years ago. Four types were given, and the running costs in the air were as follows:—

Type A	... ...	$2\frac{1}{4}$d. per mile.
Type B	... ...	$4\frac{3}{4}$d. ,,
Type C	... ...	$5\frac{1}{2}$d. ,,
Type D	... ...	$3\frac{1}{2}$d. ,,

These figures, of course, refer to peace times so far as cost of petrol, etc., is concerned, but it refers to an old type of machine with about half the speed of the present-day machine. Repairs should cost less, if anything. I have further taken out the running cost per mile in the air of late types of machines of which I have intimate knowledge. These machines may all be put down as doing considerably over 100 miles an hour, but we will take them as covering 100 miles an hour, although personally I think that the wind will average itself, that is to say, one day it will be against and another day with the machine. The cost of these machines in the air is as follows:—

		per mile.
A.	Carrying useful load of 1,800lbs., including pilot and fuel ...	6½d.
B.	,, ,, ,, 1,000lbs., ,, ,, ,, ,, ...	5d.
C.	,, ,, ,, 450lbs., ,, ,, ,, ,, ...	2½d.

Now in talking about the cost of aircraft as compared with other forms of transport I have so far only dealt with the running costs and have shown you how very cheap it is, but in order that the whole of the aeronautical industry should not leave the room to register aerial transport companies, it is necessary to go into figures much more deeply, as there are other costs besides running costs. On the other hand, it is necessary to remember that before you can use a motor-car, or a motor-lorry, you must have a road on which to run it, and the average cost per mile of this road in capital expenditure alone may be put down as about £6,000 per mile.

A railway train before you can run it requires a capital expenditure which, taking the average of various countries, may be put down as £24,000 per mile.

FIG 2.

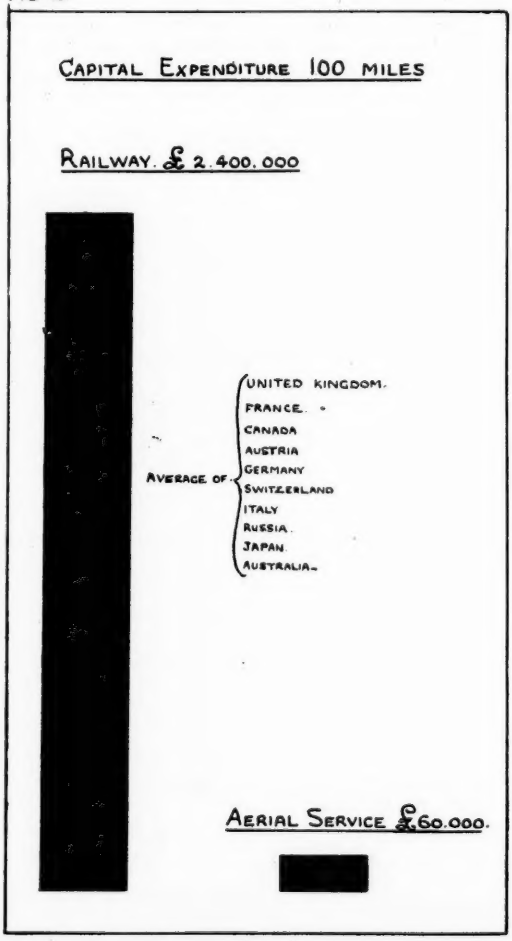


FIG. 2. CHART.

Taking, therefore, a journey of, say, 100 miles, as we must have some unit, the capital expenditure, apart from running cost, comes out as follows :—

	£
Railway	2,400,000
Aircraft	60,000

I do not for one moment suggest that, once the capital outlay on the railway has been made, it will not carry, to a huge extent, much more traffic than the aeroplane line, but until that traffic is forthcoming the aeroplane will, firstly, do it without such capital expenditure, and secondly, will always do it very much faster.

The natural obstacles encountered by the railway and the road may be unsurmountable. The air is free of any such obstacles.

I will now take you through the costs of a sample route, and I suggest London—Paris as an instance. We can take it that if the journey is done in half the ordinary time we shall have mails and passengers—some because they want to get there quickly, others because they wish to avoid the Channel crossing, and a good many, at first, for curiosity. Now to start a Commercial Service we are not asking for millions of passengers or tons of mails; we are not thinking of rivalling the Tubes.

In putting these before you I would make it quite clear that they are costs of to-day, which I think it is right I should take, as if I begin to prophesy you will doubt me at once. At the same time I have not the slightest doubt that these figures as times go on will come down enormously just as the cost of running omnibuses has come down since the time when the first petrol omnibuses nearly ruined every company running them, and I would like to say without much misgiving that within a certain period you may halve them.

FIG. D. AERIAL SERVICE, LONDON—PARIS.

One machine each way daily.

Carrying 2,500lbs., less Petrol and Oil and Pilot, for, say, 300 miles

		per mile. s. d.
Capital—		
9 machines at £2,500	£22,500	
Working Capital, say	12,500	
	£35,000	
= 2,000lbs. for Utility Purposes.		
Machines—		
London	2	
Dover	1	
Calais	1	
Amiens	1	
Paris	2	
Spares	2	
	9	
At 10% interest per annum, £3,500, or £9 6s. 8d. per day for 600 miles		0 3½

		per mile. s. d.
Sheds—		
London	£500	
Dover	200	
Calais	200	
Amiens	200	
Paris	500	
	£1,600	
Say £4 10s. per day for 600 miles		0 2
Labour—		
London	12 men	
Dover	2 ,,	
Calais	2 ,,	
Amiens	2 ,,	
Paris	12 ,,	
Total ...	30 men	
At £3 10s. per week equals £15 per day for 600 miles ...		0 6
Pilots—		
3 flights one way per week per Pilot requires for 14 flights per week 4½ pilots, reserve, say, 1½ Pilots, equals 6 Pilots at £500 per annum each equals £3,000 per annum, say, £8 5s. per day for 600 miles		0 3½
Running Expenses—		
24 gallons Petrol and 5 gallons of Oil, taking speed at 100 miles per hour		0 8
Depreciation and Repairs—		
Allowing complete overhaul every 100 hours, flying 300 miles per day at 100 miles per hour equals overhaul every 33 days. 25% off two machines at £2,500 each equals £1,250 equals £38 per day for 600 miles ...		1 3
Overhead Charges—		
Management	£3,000	
Clerical Work, etc.	1,600	
Advertising, etc., each end	6,000	
Offices, etc.	1,000	
Contingencies	2,400	
	£14,000	
Say £40 per day for 600 miles		1 6
Total cost per mile ...		4 8

FIG. E.

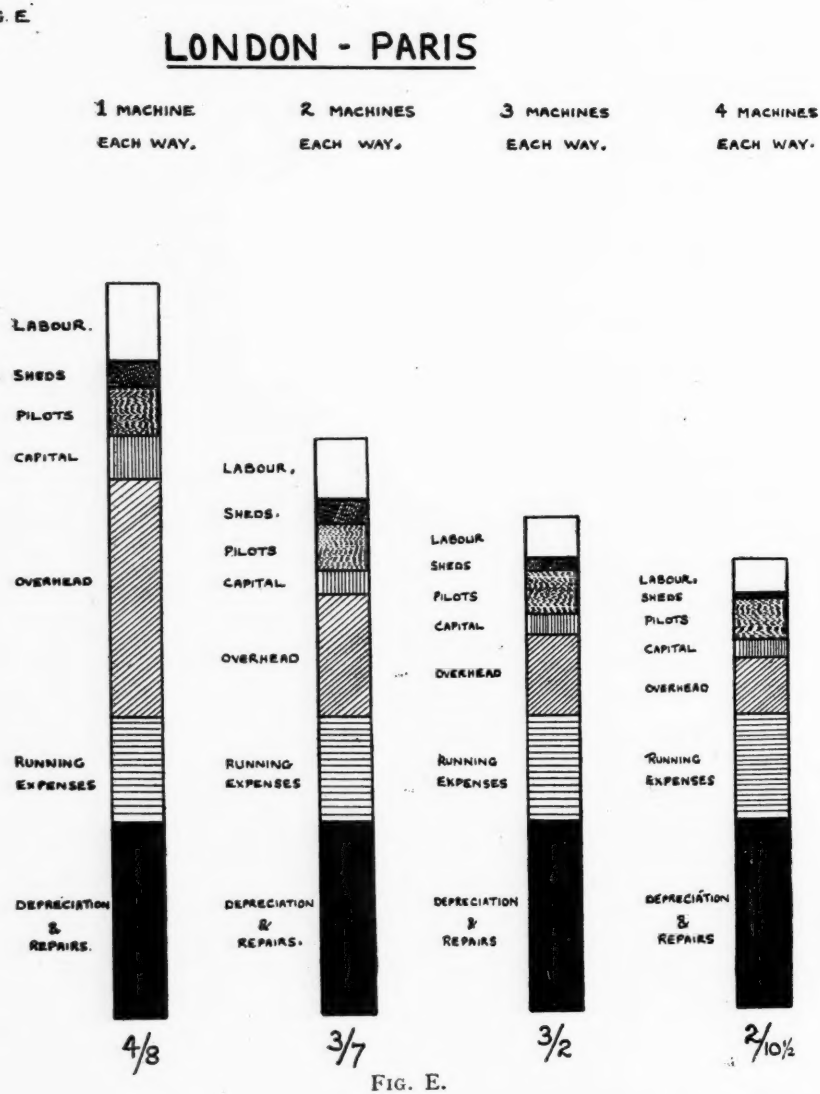

LONDON - PARIS
1 MACHINE EACH WAY.
2 MACHINES EACH WAY.
3 MACHINES EACH WAY.
4 MACHINES EACH WAY.
LABOUR.
SHEDS
PILOTS
CAPITAL
OVERHEAD
RUNNING EXPENSES
DEPRECIATION & REPAIRS.
4/8
3/7
3/2
2/10½

FIG. E.

FIG. 3. PARIS—LONDON.

Profit and Loss.

Passengers—
Cost, say, 3s. per mile.
300 miles = £45.
2,000lbs. = 12 Passengers.
Cost per Passenger, £3 15s.
Charge per Passenger, £5.
Profit per Machine each way daily, £15.

12	Passengers	each way,	4 machines.	Profit,	£43,000	per annum.
11	,,	,,	,,	,,	30,000	,,
10	,,	,,	,,	,,	14,000	,,
9	,,	,,	,,	,,	—	
8	,,	,,	,,	Loss,	14,000	,,
7	,,	,,	,,	,,	29,000	,,
6	,,	,,	,,	,,	40,800	,,
5	,,	,,	,,	,,	58,000	,,

and so on.

FIG. G. PROFIT AND LOSS.

Mails—
Load, 2,000lbs. = 32,000ozs.
Cost per oz., ½d.
Charge, say, ½d.
Charge, 3lb. parcel, 2s.
Full load each way, 4 machines. Profit, £60,000 per annum.
Three-quarter load each way, 4 machines. Profit, £14,000 per annum.
Half load each way, 4 machines. Loss, £35,000 per annum.
and so on.
Total cost of 4 machines each way, £130,000.

FIG. H. LONDON—MARSEILLES.

8 hours.
Passengers, £10.
Mails, 1d. per oz.

LONDON—CONSTANTINOPLE.

20 hours.
Passengers, £25.
Mails, 2½d. per oz.

Now you will have seen from these costs that I have put before you that passenger services are not high for the speed of journey, and present a really commercial proposition, although at a competitive price they are slightly higher than by train and boat, whilst mails present an easier proposition, and it seems to me that the solution is a mail service subsidised by the Government with the right to carry passengers.

It is certain that the aeroplane is going to be used by business men for business purposes. No other mode of transport can touch it. Whether it costs 5s. per mile or £5, the business which can be done on certain occasions will only be done by arriving in time.

It will be seen from Fig. D. that the total cost per mile of running a machine is 4s. 8d., running one machine each way. By reference to Fig. E., however, it will be seen how rapidly the cost comes down if two, three, or four machines are run each way daily, and I think it is fair to assume that between two capitals,

such as London and Paris, at least four machines each way will be necessary, and we can therefore for the purposes of this paper take 3s. per mile as being a safe figure.

Fig. F. shows how this cost, reduced to passengers, will come out. It will be seen that the charge per passenger to Paris, at a profitable rate, so long as the machines are fully loaded, comes out at £5, which at the speed he is carried is certainly a commercial price. It will be noticed here by the figures shown at the bottom that whilst there is a good profit if the machines are full of passengers, a reduction in the full load very easily turns the profit into a loss, and this is one of the points which will have to be considered very carefully indeed. The services *must* be started, and either subsidies or guarantee against loss *must* be forthcoming.

Fig. G. shows that mails are even more commercial; that is to say, a letter weighing one ounce can be profitably carried to Paris for one halfpenny in half the time it could reach there under the present methods, or a 3lb. parcel for 2s. Here again it will be seen that profits can be made carrying full loads, but directly the load is reduced it is quite easy to make a heavy loss.

From Fig. H. you will see that, based on our London—Paris costs (Fig. D.), passengers can go from London to Marseilles in eight hours instead of 23, at a cost of £10 per head; or that mails can be carried at a penny per ounce.

Constantinople or Moscow can be reached in 20 hours, at a cost per ticket of £25; or mails at 2½d. per ounce, both of which I think proves still more the future of commercial aeronautics.

For mail services I am certain that the aeroplane can by its speed and moderate cost per letter compete with existing mail services. I have always held these views, and they are expressed very simply by the fact that I arranged with Mr. Grahame White seven years ago to carry mails from Blackpool to Southport, and endeavoured to interest the then Postmaster-General in it. Specialised services of all sorts will exist also. I have taken the cost of London—Paris, as it is a familiar route, and probably the most expensive, but there is another outlet for commercial aeronautics than from capital to capital, viz., providing a means of communication by which at comparatively small cost a moderate-sized community or colony may be established, say 100 miles from the railway, in many of our Overseas Dominions, and whilst small will depend on the aeroplane, and when grown large enough will have its railway. In other words, the new science of flying may be regarded as a means of development, as a feeder for the railways existing, or without laying a road at all either for motor-cars or railways, until development warrants them. Certainly on the start of such services a Government subsidy or guarantee will be an absolute necessity.

Now another thing which you may doubt, but of which I have had considerable experience, is reliability. You can gauge this in any way you like. How many machines cross the Channel daily? How many machines fall into it? I am afraid I cannot answer these questions, but perhaps some enterprising Member of Parliament present will put the question in the House. But within my own experience, even with machines not nearly so reliable as those of to-day, I have no doubt about the reliability. My Company, The Aircraft Manufacturing Company, has been in existence since 1911. It has delivered—I cannot tell you the number—but a great many machines to Farnborough. The only stops we can record are in four cases, and in every case these were only ordinary stoppages, such as in the case of a car, with a choked petrol pipe, or something of that sort. I will also give you a few recent instances of practical uses of aeroplanes, again within my own knowledge, although I am certain these would be confirmed and multiplied if I were to ask outside.

A short time ago the War Office required one of our managers at Chelmsford for a certain purpose. They telephoned at about 11.20 saying that it was

absolutely necessary for him to be there by 12 o'clock. Here is an instance where aircraft presented the only means of transit. Again, a recent instance is a case where the War Office telephoned asking Captain Hucks to go to Huntingdon to test a machine for them. The actual distance there and back is 116 miles, and Captain Hucks' flying time there and back was inside an hour. I believe General Brancker, time after time, has visited various aerodromes by air, putting in visits during the day which would be perfectly impossible with any other mode of transit. I met Captain de Havilland one evening at Boulogne by accident, he having flown from Farnborough to Headquarters in 1 hour 25 mins., and he tells me that this must have been surpassed many times.

Another point which will be brought up against flying for commercial purposes is weather, and this we may, I think, divide into wind and fog.

Now as to wind, it is to-day almost safe to say that no wind will stop a good pilot from flying. Over and over again we find in the official communiqués that during hail, snow, and storm our pilots are flying. Again, however, taking only my own experience, I will show you a wind in which flying was possible in pre-war days.

Now in this case the speed of the machine was about 60 miles per hour, and the machine, although blown to a standstill so far as speed through the air was concerned, was still flying. To-day our machines double easily the speed, and

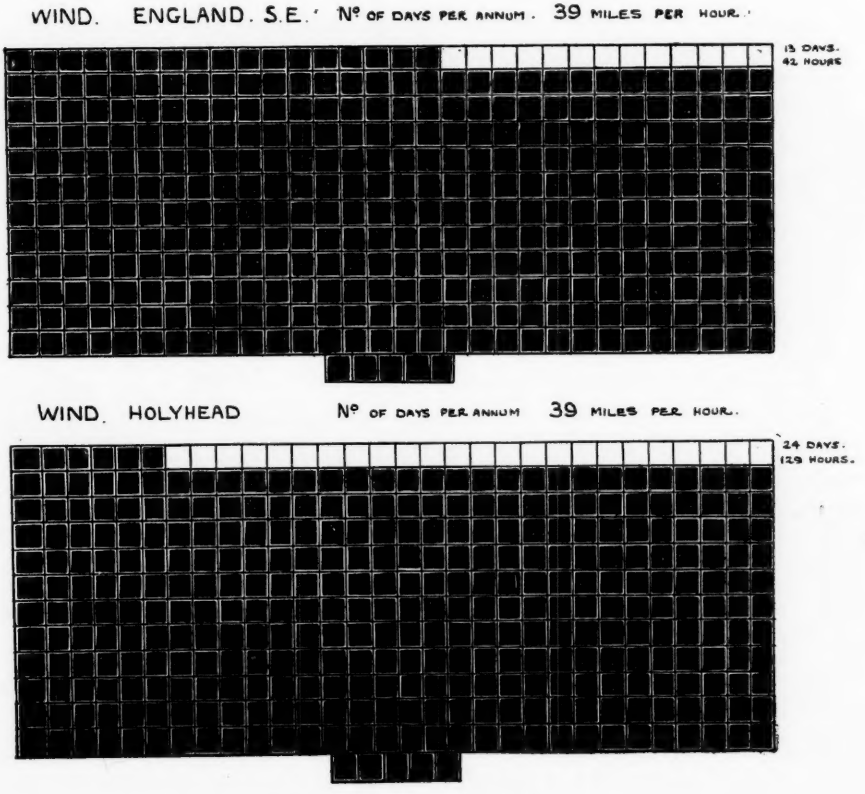

WIND. ENGLAND. S.E. Nº OF DAYS PER ANNUM. 39 MILES PER HOUR.
13 DAYS.
42 HOURS
WIND. HOLYHEAD Nº OF DAYS PER ANNUM 39 MILES PER HOUR.
24 DAYS.
129 HOURS.

FIG. 4. WEATHER CHARTS.

therefore in the same wind still leave behind them 60 miles of distance covered. Wind is very much overrated owing to the difficulty in flying in a breeze in the early days, and I am going to show you a chart giving the proportion of days in the year on which the wind was over 40 miles an hour, which would still leave a present-day machine 80 miles an hour for covering distance. You will see that even if aerial services stop, which they certainly will *not* do, altogether on these days, it only means that for a comparatively small proportion of the year commercial aeronautics will revert to more ancient modes of transport.

Fig. 4 gives, by a diagram, the days in the year on which the record for South-East England, of a wind of 39 miles an hour or over, is recorded. The black squares represent 365 days in the year, and it will be seen from the white squares that only 13 days are recorded in the year with a wind of 39 miles an hour or over, and if divided into hours, only 42 hours in the year. Taking one of the worst instances, viz., Holyhead, it will be seen that there are 24 days recorded in the year only, so that if you assume no flying takes place on these days it does not seriously detract from the advantages of commercial flying. Personally I do not think a wind of 39 miles an hour will stop an aeroplane at all, and I give a recent instance, viz., the presentation of a machine to South Africa, only a few days ago, at which I was present. On that occasion I thought the wind was fairly strong, and I therefore asked the Meteorological Office to let me have a record, which shows 39 m.p.h. Now on this occasion, as people will remember, nobody thought about the wind at all. Captain Hucks was flying all the time, taking passengers, looping the loop, etc., and certainly if he had been asked to start for Paris that afternoon he would have thought nothing of it.

The next thing is fog, certainly a bugbear, but even here you will see that it is not so black as it is painted, and again means that, even if we stop flying altogether in a fog, commercial aeronautics has still an existence. But with our aerial landing grounds in existence no notice will be taken of local fog if our reports show that generally the line is clear. For many years, if there is a fog at Hendon, which is usual, owing to the lie of the land, we have taken no notice on long trips if our reports show the fog is only local, and our aerial service reports from all the landing grounds *en route* in foggy weather would be part of our business in conducting an aerial service.

Again, if foggy in London we might start from Dover only that day, forwarding the mails then by car or train, or again, we might convey the mails even to Calais, and thence on by aeroplane. Necessity is the mother of invention, and I look to overcome difficulty in this respect.

Fig. L. again shows the record of the Meteorological Office, and it will be seen that, taking the figures for the South Coast, omitting Scilly, at 7 a.m. there are only 12 days in the year on which fog is recorded; at 1 p.m. only five days (which shows that the fog has cleared off); at 6 p.m. five days; and at 9 p.m. four days in the year. On the right-hand side of Fig. L. the record for London at 7 a.m. is shown, in which you will find only 22 days recorded out of 365. These records are presumably correct, and I believe that we attach a great deal more importance to fog than we need. If one casts one's memory back to how many times one's train is delayed by fog, and how many times even an aeroplane is delayed by fog at the present time, I am sure that we look on this matter as more serious than it is. Again, however, the question of landing grounds will also largely affect fog. I have recently combined with a flying officer in the production of a very small kite-balloon carrying no passengers, and I believe in case of fog or night work one of these sent up, say, 1,500ft., *i.e.*, above fog, would practically solve the difficulty if the landing ground scheme to which I will allude later is adopted.

I have mentioned the questions of safety, weather, and fog, etc., as previously to the war I was merely looked on as an enthusiast, and none of my friends

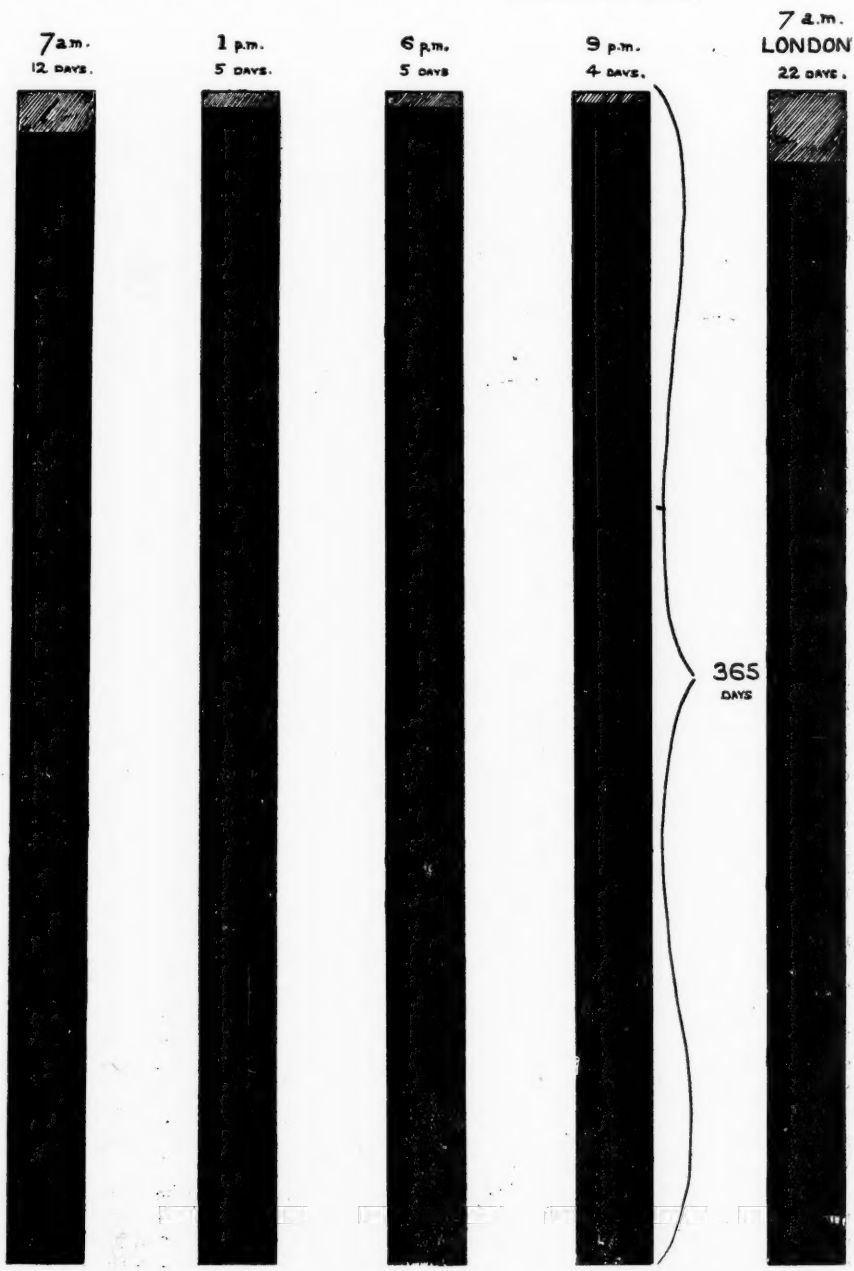

FOG. SOUTH COAST (OMITTING SCILLY) Nº OF DAYS PER ANNUM.
7 a.m.
12 DAYS.
1 p.m.
5 DAYS.
6 p.m.
5 DAYS
9 p.m.
4 DAYS.
7 a.m.
LONDON
22 DAYS.
365
DAYS

FIG. L.

believed in aviation. Since the war public opinion has entirely changed. The man in the street no longer looks on an aeroplane as something on which somebody is mad enough to do acrobatic feats, but has a very decided belief in aircraft for *war* purposes, and my purpose to-night is to persuade you to believe in it for *commercial* purposes, and I hope that nobody will leave this hall to-night without being so convinced.

I should now like to touch on a subject which, in my opinion, is very important to commercial aviation, viz., the question of landing grounds, and my view is that we shall have to establish landing grounds all over the country and all over the world not more than, say, 10 miles apart. In talking, say, of a voyage from London to Constantinople, this sounds a stupendous undertaking, but if analysed one finds that it is quite simple.

Allowing £250 per annum as the cost of hiring and maintaining a landing ground, it means that from London to Constantinople, 1,600 miles, the landing grounds would be 160, which at £250 per annum each would be £40,000 per annum. What is this spread over the countries through which this route would pass, assuming the importance of having this very vast connection all over the world? But looking at it in another way, even if the cost of a landing ground was paid by the machine which passed over it, it is almost an infinitesimal matter. Taking our previous figures of London—Paris, with eight machines per day, *i.e.*, four each way, the number of machines passing over the landing grounds between London and Paris would be 2,920 per annum, and a tax of about 2d. per mile on each machine would return the whole costs of the landing grounds. But the London—Paris route will also be the running line for many other services beyond Paris and London.

I regard the landing grounds as being of the greatest importance. To start with, no country can have machines flying over it without control, and therefore a landing ground on entering a country is necessary, putting it on the lowest ground even of smuggling goods into the country. Then again, I believe if I asked anyone in this room to fly from London to Tokio they would say "You will never arrive there," but on the other hand, if I asked them to fly 10 miles, they would know that they would certainly arrive; and therefore to credit what I have told you so far, I am going to tell you it is important to regard these long distances as merely 10-mile stages. This question of landing grounds affects every point in my argument. Safety, for instance. The forced landing, the bugbear of aviation, will be avoided, as a pilot with a machine at a height of 3,500ft., even if he stops exactly in the middle of two landing grounds, will arrive at either, but the probability is that he would be very much nearer one. We may therefore consider London to Tokio as aerodrome flying—that is to say, the pilot will always have a flying ground to alight on. As regards the pilot, he will have no strain in keeping his eyes open for a landing. He will simply fly on, passing Flying Ground No. 27, 28, 29, etc., knowing that he is always safe if his motor stops at any moment.

Then again, the question of fog will certainly be overcome at once by 10-mile landing grounds. Some form of mark will easily be developed, such as a smoke signal, some form of penetrating searchlight, or some other device, such as the small kite-balloon I have recently devised.

The question of night flying is again solved by the landing ground, as with a searchlight every 10 miles a pilot can fly on regardless of maps or routes, always with the searchlight guiding him.

I am not, of course, suggesting that landing grounds should be aerodromes; they would be simply suitable fields, which need not be absolutely on the line of route, with probably a telephone box, and some with searchlights, and some with sheds. This scheme has already been carried out in Italy, and has been entirely successful, as I believe I am safe in saying that the cost of the landing ground

has practically been repaid by the saving in smashes on landing in what is a somewhat difficult country. By the courtesy of Major Perfetti, of the Italian Flying Corps, I am able to give you an illustration of a portion of the map showing the landing grounds, etc.

Now I will ask you to accept this idea of the 10 mile landing ground as being perfectly feasible from a national point of view and from an international point of view, but it is a matter in which Great Britain and the British Empire should take the lead.

The landing ground scheme also presents a method of avoiding collision in the air, which is bound to happen if no arrangements are made, and it would be very simple for an outward pilot to keep to the right and an inward pilot to keep to the left. Then again, once you accept this proposition, even crossing the Atlantic becomes feasible. What is to prevent us having a ship, not necessarily anchored, but always cruising, say, every 50 miles from the Azores to Newfoundland. On the North Sea you will find the pilot cutters which are there from one end of the year to another, with the pilots awaiting inward and outward bound ships. Compared with the enormous scheme a mail between London and New York will present, the cost of 10 or 20 ships (which may be simply fixed lightships if feasible, or small cruising ships if necessary) is infinitesimal.

I understand that the number of week-end telegrams, 4s. 6d. for 25 words, which are not able to be sent because the lines are so full, is enormous, but this is nothing compared to the tonnage of mails which would be available if they could be carried from London to New York and *vice versa* in two days.

It is harking back to a very long time ago to the Pony Post in America, but in Mark Twain's " Roughing It " you will find an account of letters being carried 2,000 miles in eight days at the cost of £1 per letter. This really is very much the system of an Aeroplane Mail, but at a commercial rate and enormous speed. The riders galloped night and day, winter and summer, 10 miles stages, using a fresh pony for every stage. They were apparently, even in those days, streamlined, that is to say, the mail packets were fitted to the rider's body. Again like an aeroplane, they carried no extra weight, they used a racing saddle, and wore light shoes or none at all. The letters were written on paper as thin as gold-leaf

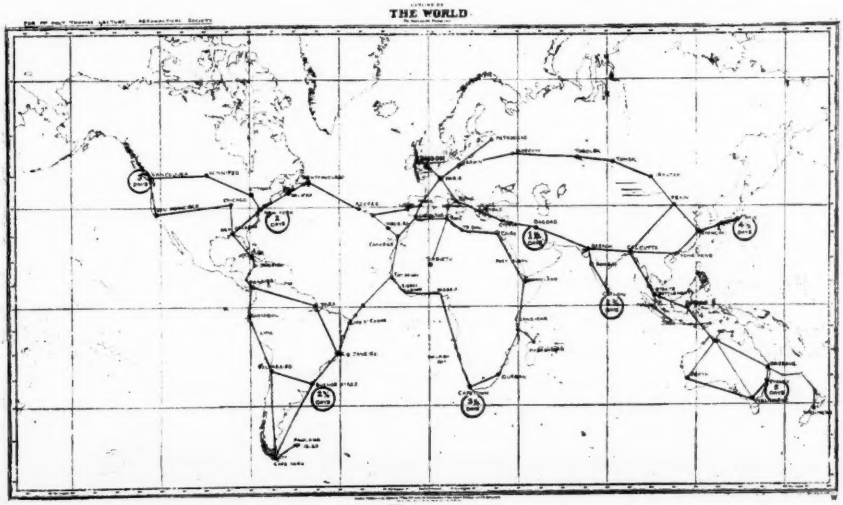


FIG. 6.

and thus bulk and weight were economised. Eighty pony riders were in the saddle night and day, stretched in a long procession from Missouri to California, forty flying eastward and forty westward, and using amongst them four hundred ponies. So will the Aeroplane Mail soon traverse the world in stages, some being stations, others being passed over.

I will presume that you have now accepted this principle, and I now propose to show you a map of the world, on which I have shown routes which you assume will be covered with 10-mile landing grounds. Once assuming that, I believe you will accept my previous figures on commercial aeronautics as a perfectly feasible proposition. You will see then what an enormous thing commercial aeronautics represents, and what a revolution in speedy transit. Ceylon becomes $2\frac{3}{4}$ days from London, Tokio $4\frac{1}{2}$ days, Sydney 5 days, Cape Town $3\frac{1}{2}$ days, Vancouver 3 days, and so on; and once you have accepted the premises on which I started you will admit that I am only putting before you propositions which are perfectly easy to carry out.

You will see on this map that I have marked Timbuctoo, which sounds the most improbable place that anybody would wish to arrive at, but strange to say it is one of the places where an aerial service is already projected by the French, which really affords a very good instance of the use of the aeroplane. At the present moment it takes three to four months from Bordeaux to Timbuctoo, and owing to this the many officers employed spend half their time going and coming. The cost of this journey at present is £120, and it is estimated by a friend of mine in the French Government, who has given me this plan, that it could be done by aeroplane for £100 per journey, and taking it in easy stages it would only be a matter of days instead of months.

Instances in the Overseas Dominions, where not yet developed, we shall find

FIG. N.

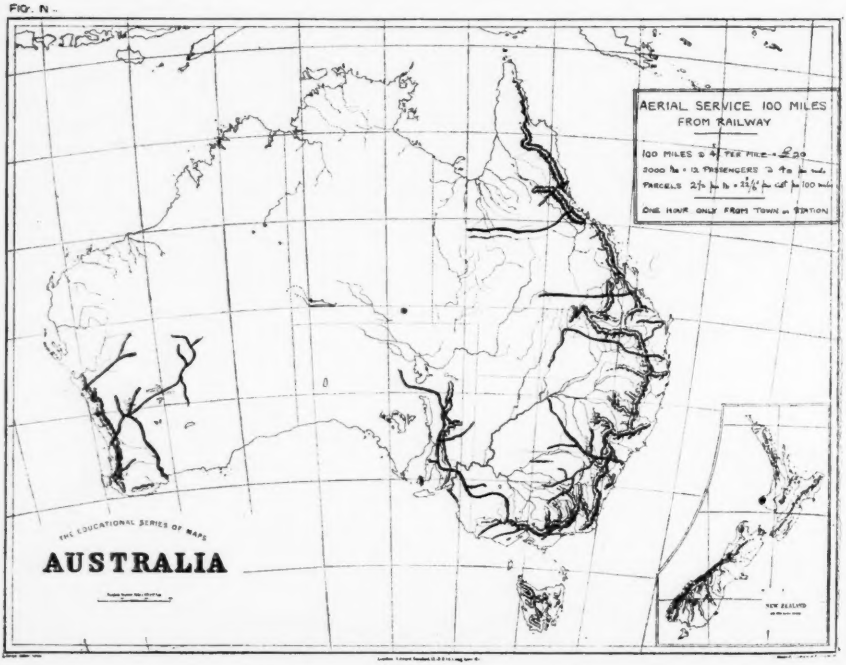

AERIAL SERVICE 100 MILES FROM RAILWAY
ONE HOUR ONLY FROM TOWN or STATION
THE EDUCATIONAL SERIES OF MAPS
AUSTRALIA
NEW ZEALAND

FIG. N.

in hundreds, where the aeroplane can be used, but I show you in Fig. N, as an example, a map of Australia, showing you the railways marked on it. You will see that an aeroplane service on each side of any of these lines of 50 to 100 miles would certainly mean the establishment of a great many small townships, which eventually, when big enough, will of course have their railway. This, coming down to pounds, shillings and pence, presents an absolutely commercial aspect, as shown on the map. A passenger from the township to the railway, or *vice versa*, can be carried profitably at fourpence per mile, which is a little more than first class fare in this country. Mails and goods can be delivered at 2½d. per lb., and this applies to all the Overseas Dominions.

One point I should like to disabuse everyone on at once is the discomfort of an aeroplane. At the present time it is not, of course, suited for carrying a large

FIG. 8. THE FUTURE AERIAL MAIL.

number of passengers, but I have gone carefully into this problem with my drawing office, and allowing for the reduction in speed the alterations will necessarily make, we find that it is perfectly easy to design a comfortable cabin in which passengers would be quite as much at their ease as by any other method of transit. When, therefore, you come to the discomfort of a shaky train, the dirt, and the annoyance of changing from train to boat and boat to train, etc., you will find that the comfort of the aeroplane is easily superior to the discomforts one goes through on an ordinary journey to-day. You will later on, on the cinema films, see the interior of the big Porte Boat, built by my company, and you will see that already we have a machine which has a commodious cabin.

Now I should like to explain that my figures and my fancies this evening have been based on present day machines, but we must take into account that the aeroplane has only really been encouraged since war began and for war purposes. It is therefore fair to assume that the aeroplane has developed along entirely

wrong lines from a commercial point of view, and the present design is wrong (thinking commercially) for the following various reasons:—

1. Excessive climb demanded in a fighting machine, and power thrown away to obtain this.
2. Excessive attention devoted to visibility, gun positions, etc.
3. Excessive strength for fighting manœuvres, etc.

The present unpleasant features of an aeroplane, *i.e.*, noise, oscillation, cold, cramped positions, are all due to war design and can all be eliminated in a passenger-carrying aeroplane without reducing this speed very much, but only by sacrificing climb, visibility, guns, etc.

In criticising the cost of running an aeroplane service and comparing it with train service or ships, one ought to consider how very unpractical and useless

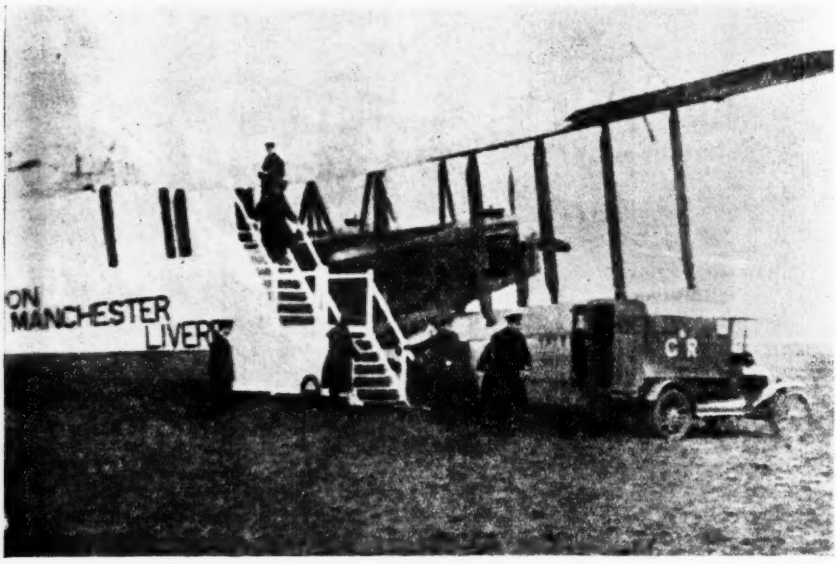


FIG. 9. PARCEL POST.

the first trains or ships were, and how exceedingly unpleasant travelling in them must have been. Passengers in the first train, I believe, were just as cramped as they are to-day in an aeroplane. The oscillation was greater, they were covered with smoke and cinders and the speed was limited to the rate at which a man could walk in front with a bell.

The early ships were equally unstable, and it was a very doubtful point when a ship set out if it would arrive at its destination, if ever.

If one reads any of the accounts of the early voyages one is struck by the fact that very frequently they set out from a place and returned six months later, having met adverse weather, and it was the custom to say Masses for anybody who thought of doing anything so hazardous as going a sea voyage.

The safety of the present steamship transit, I would submit, is due in the first place to engine development; also to the fact that every country has spent

millions of money in harbours, lighthouses, docks, shipyards, etc., etc., and for an aeroplane service exactly the same steps will have to be gone through to ensure success for the commercial aeroplane.

Looking a good deal ahead one point occurs, *i.e.*, that the geography of the upper air is at present quite unknown, and assuming the large aeroplane comes into use with reliable, powerful, and compact engines, it is reasonable to suggest that steady air currents, etc., may be found which would enable the trip to be made at a much greater speed and with much greater power than is at present even anticipated and consequently much greater economy.

It is essential that the Allies at once institute what may be called the " Allied Aerial Route " all over the world, without passing over Germany, so that at the end of the war, whilst our routes must perforce be used by the Germans, it is quite unnecessary for the Allies to use any German route.

The sea, presumably, is free to the whole world, outside the three-mile limit, and we cannot keep German ships off the sea; but presuming that the air goes with territorial rights, we shall be able after the war to prevent German machines passing over Allied territory. If you look at the map of the world you will see it is covered, firstly, with the British Empire, and secondly, with the British Empire and land belonging to our Allies, whilst Germany is of not the slightest use to us.

Now all I have been able to do to-night is to give you something to think over, something to digest; but I hope I have proved that flying has come to stay, and must from an Imperial point of view be supported in every way. Mail services, as I have shown you, can be established commercially; business men can use the aeroplane commercially for many purposes, and for pleasure nothing can beat it. I have arranged a somewhat imaginative cinema film showing you something of what an aerial service will look like, and the last thing I have to say is this. Remember that we live on an island, remember that we have always depended on the sea for our protection, and last but not least, remember that we are an Empire. On all these points it is necessary to maintain a huge aerial fleet, and the proper support of commercial aeronautics will enormously assist these ends. *This* time we *must* be first.

*** *The discussion on Mr. Holt Thomas' paper will be found on page 420.*

A FURTHER THREE YEARS' FLYING EXPERIENCE.

BY CAPTAIN B. C. HUCKS.

Ladies and Gentlemen,—I think perhaps the title of my paper requires a short explanation before beginning.

A little over three years ago I was honoured by being asked to read a paper on flying before this Society, which I then called, "Three Years' Flying Experience." I need hardly say that paper caused me no small amount of anxiety in preparing, even then, when a mere description of an ordinary flight would deeply interest most people, because when I came to get down to it I had to ask myself what there was I could find to talk about that would interest the learned and technical audience I knew I should have to face.

However, the paper was read, and I suppose it gave satisfaction, because a short time ago I found the Society like Oliver Twist, "asking for more."

So as to give myself plenty of scope to-night I have called this paper, "A Further Three Years' Flying Experience," and certainly its preparation has caused me no less anxiety than on the first occasion. The past three years, although normally a short space of time, yet measured by the advance of aviation, has been a veritable lifetime. Many thousands of people are now deeply engrossed in the subject. Most of you who have honoured me with your presence here to-night have studied flying from the very highly technical and scientific side, in fact far too technical and scientific for me, and you certainly know a great deal more about the subject from that point of view than I do. It is to you, gentlemen, that I tender my apologies, and I think that when you received particulars of this evening's programme, some such notice as "laymen only need attend" should have been appended. I hope that this plain, non-technical account of things, hardly touching upon the war, connected with my flying which has been brought to my notice during these three years, may interest you a little and perhaps form the basis of a discussion.

Progress.

I think I am right in saying that through the war aviation has advanced more than it would have done in eight or ten years of peace conditions. In fact the rate of improvement in aircraft is so fast, the pace so alarmingly rapid, that it is almost impossible for manufacturers to keep pace, for it seems that by the time the latest and most efficient type of machine is manufactured in sufficiently large numbers to gratify half the requirements of the Services, that type is out of date and obsolete. That you may realise at a glance the remarkable strides that have been made over this period, I will show you some diagrams, which, without giving any figures that may be military secrets, should convey a fair idea how the capabilities of aircraft have improved. I have taken the average performances of five different types of service machines used at the beginning of the war and compared them with the average performances of five different types of late patterns now in use in France.

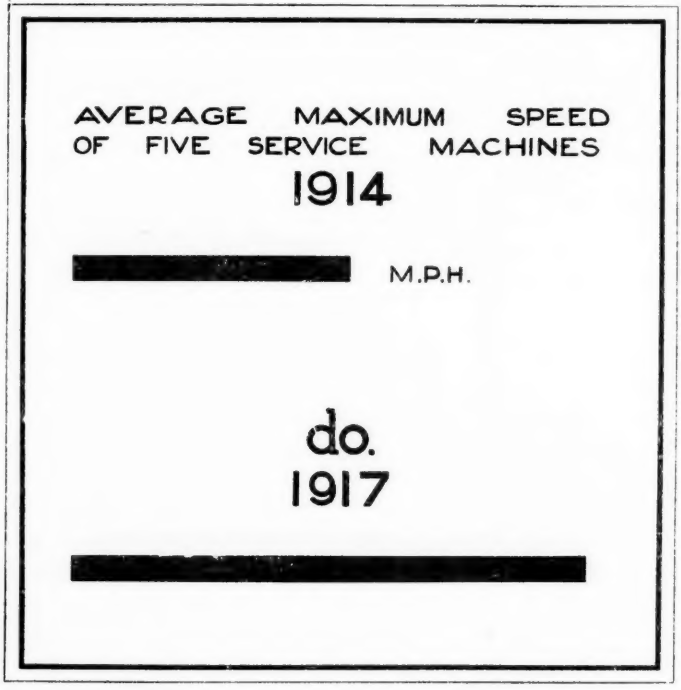
The first diagram represents the growth in three years of the maximum speed capacity flying level.

The second diagram consists of two curves showing the increase in machines' capacity for climbing against time.

The next diagram represents the growth of horse-power developed by aero motor engines.

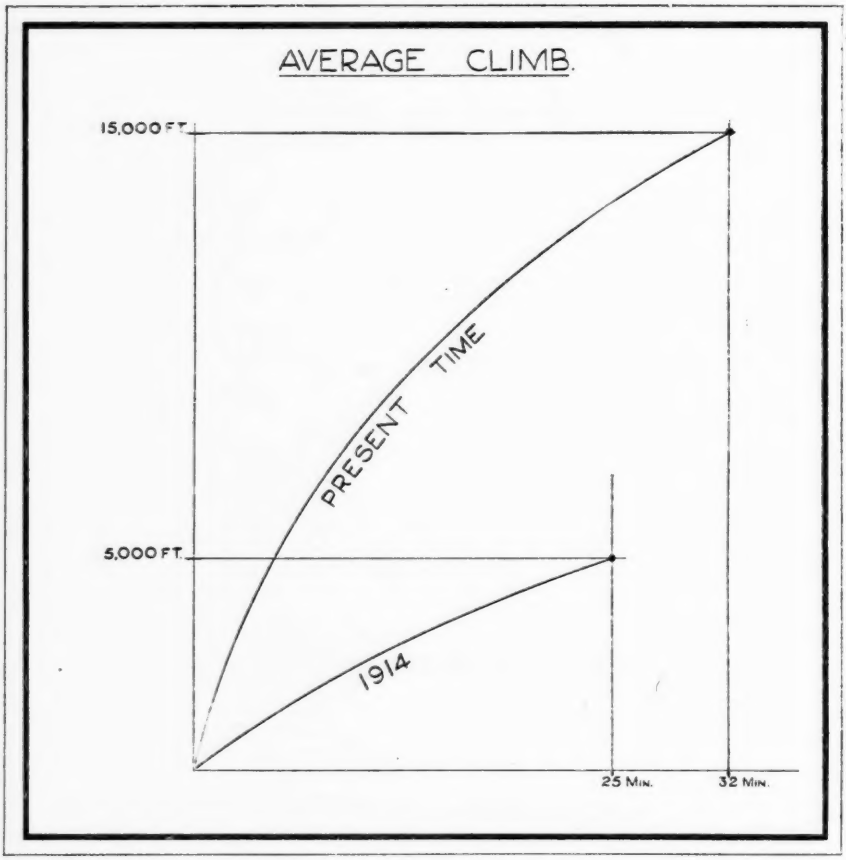
And lastly, the increase in the number of certified pilots during the past three years.

A pilot has only to take a short flight on a 1914 type machine and then fly the latest 1917 pattern as a comparison to really appreciate this colossal advance.



Some little time ago I had occasion to again fly, after a considerable lapse of time, a 50 h.p. Gnome Bleriot, a one time premier machine, in fact a type used quite a lot by ourselves and the French at the very beginning of the war. At first I believed the machine to be a very bad specimen of the species, but ultimately, after flying it for some time and acquiring a sort of lost art of balance, like a skater who has not skated on ice for years and has to get his legs again, I realised that it was quite a good specimen of the type, but that it takes quite a time to again get used to such inefficiency. The advance seems to have been along, one might say, quite conventional lines, that is improvements on what might be accepted as standard designs, and no good results have been obtained from any departure from that standard. Perhaps the furthermost departure from what I call standard, and that is very slight, has been the triplane. The results obtained with the quadroplane have not justified the experiment.

During the past three years the first marked improvement, to my mind, which asserted itself was the inherently stable machine, attained apparently by such slight detail alterations as sections of planes and elevators that it required an experienced eye to detect a stable or unstable aeroplane by casual inspection when standing together. Then came the synchronised timing gun-gear which enabled the machine guns to be fired through the propeller on tractor machines. This device is really so simple that one is at a loss to understand why it had



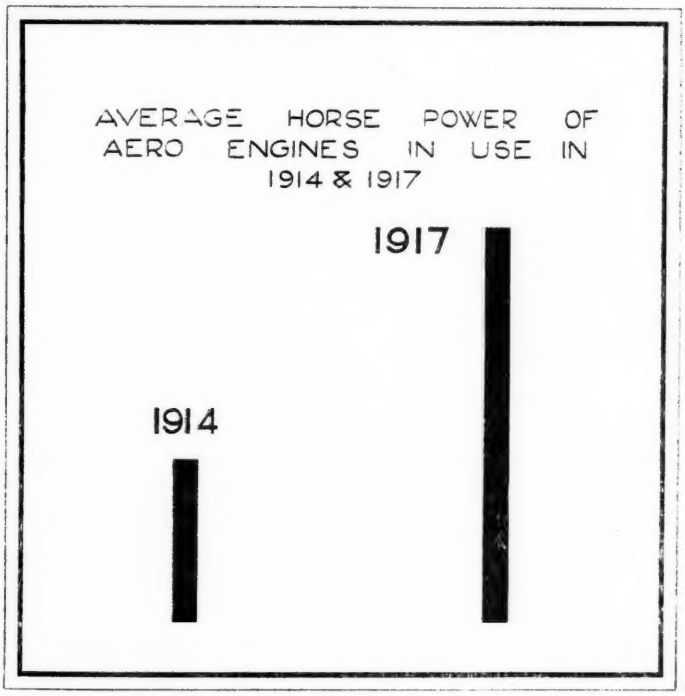
remained so long undiscovered. It had the effect of giving the tractor type of machine a new lease of life; although a more efficient type aerodynamically than the pusher, it had been falling into disfavour as a fighter on account of the inability of the pilot to shoot straight ahead of the machine.

Improvements in engines, to my mind, are responsible for present-day performances to a far greater extent than improvements in machines, chiefly through sheer increase of horse-power, as my diagram shows. And cases have occurred where certain obsolete types have been made serviceable simply by fitting an improved type of engine.

The improvements in the machines themselves seem to have been limited to details, such as wing sections, attention to head resistance, soundness of construction, etc.

The very efficient freak machine has yet to make its appearance.

I will not attempt to discuss the future of aviation, but setting aside the boundless commercial possibilities, I am more and more convinced that if we find it necessary to keep up an enormous navy, say a two-Power standard to protect our island, it will be essential to maintain at least the same standard in the air. That in itself guarantees a colossal future for aeronautics.



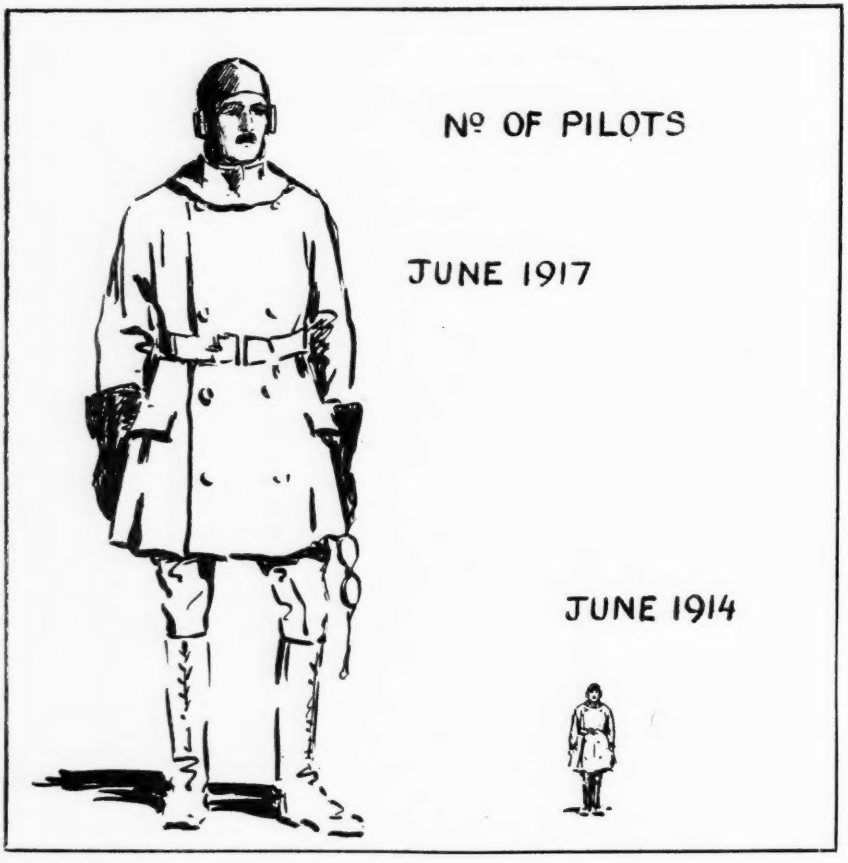
But to return to the subject of my paper to-night, I would like to place before you a few points as I have found them during a further three years of piloting.

Difference in Machines.

I have flown many different types of aeroplanes, and considering the extraordinary variations in the types the difference in the actual piloting of any modern machine, to my mind, is remarkably small. I am of the opinion that a pilot who is thoroughly efficient with any particular type will in a very short time be master of any.

I find that on stepping out of a very fast small scout into a really big twin-engine machine the difference in the manner of piloting is very slight compared with the vast difference in the machines. Precisely the same methods are

employed, the same trouble and risks are to be avoided; the chief characteristics seem to be that the smaller and faster machines are more difficult to land but are easier to handle in the air. In the case of "crashes," the larger and heavier the aeroplane the less damage there is likely to occur to the occupants as a tremendous amount of the impact is absorbed by the machine. Very much larger and heavier machines than those at present in use might be comfortably flown



single-handed, no extra effort being required for the controls, provided the controlling surfaces are properly balanced.

To the lay mind it might appear that, with such contrasts in the outward appearance of the smaller and larger machines, it would be necessary to train pilots specially and extensively for each type, but in my experience this is not so. I certainly think the best results are obtained when pilots are allowed to specialise. This, however, I understand has many drawbacks on active service.

Crashes.

Crashes are mainly due to three causes, viz., engine failure, faulty piloting,

and faulty machines. Engine failure undoubtedly is responsible for most of the crashes, often because of the hopeless unsuitability of the landing ground at the pilot's disposal. To many pilots engine failure is most disconcerting and it is then they are called upon to use rather more judgment and skill, so that even with a fairly suitable landing ground available they very often crash. In my experience, embracing the testing of hundreds of new machines, it is seldom that a serious defect in the engine "lets one down," it is nearly always due to a small detail. I think I have had to make more forced landings through failure of the petrol supply than all the other troubles combined. This is due more often to failure of the pressure feed than to a choke in the supply pipes and very seldom to severed connections in the feed system.

Because of the absence of a float chamber to the carburettor in the rotary engine, even a variation of the petrol pressure is more serious than in the rigid stationary type. In the former case the amount of petrol that gets to the motor is controlled by the pressure and a fine adjustment. If the pressure increases unduly the motor chokes from over richness of mixture; on the other hand, if the pressure drops away the mixture is unduly weakened. This variation can be controlled by the fine adjustment to a large extent; but when that limit is exceeded the engine will fail. Most of the trouble seems to be caused by failure of the pump, which in some cases forms an integral part of and is driven by the motor; in others it is a separate unit, driven by a small airscrew. These failures are usually through valves sticking up and pistons becoming dry. Other causes of failure are in the relief valve not being pressure tight or sticking down. At any rate the present system of pressure feed, to my mind, is such a bugbear that it is high time something was substituted.

As far as the non-rotary motor is concerned, to my knowledge this matter is being tackled. I have been flying recently a machine fitted with a petrol pump in place of the air pressure pump, the petrol being pumped direct from the main tank to the carburettors and the surplus is returned to the tank through an adjustable spring-loaded relief valve, so that petrol is delivered at any desired pressure to the engine. So far it has proved most satisfactory, with this advantage that a punctured tank does not put it out of action. Dirt in the petrol tank accounts for quite a large proportion of engine failures in new machines. This form of trouble ought to be avoided. It is an important matter which manufacturers should be made to recognise and a very thorough system of tank washing employed before installation in the machines.

The dirt in the tank usually takes some time to work its way into and accumulate in the feed pipes or filters sufficiently to choke them. The machines are often by that time being delivered by air by pilots who are none too familiar with them, consequently engine failure means a good chance of crashing.

I remember having four forced landings while delivering a new B.E.2C. from Farnborough to Dover on this account. Another simple cause of engine failure which might easily be guarded against is that petrol cocks in many cases have no definite locking device to ensure that they remain in the open position during flight, consequently they are liable to vibrate into the "off" position, thus cutting off suddenly the petrol supply. Many instances have come to my notice where petrol cocks are fitted in such a manner that the tendency is, through the weight of the cock lever, to fall shut intsead of the reverse. This is such a simple and yet such an important point that it really is surprising mistakes like this are continually allowed to be made. I have had engines cut out suddenly on three occasions during the past two months from this cause alone, one meant a forced landing because the petrol cock was not accessible to the pilot, the other two were opened again in the air. It often leads to serious results as the petrol fails suddenly and it is seldom that the cause is discovered before the forced landing is made. Having somewhat a limited time at my disposal this evening I will not touch on what I have found to be other causes of engine failures, but

I can assure you that as far as my experience shows they are a small proportion compared with those due to petrol supply, and improvements in this direction will reduce engine failures enormously.

Errors of judgment or faulty piloting account for nearly or perhaps as many crashes as engine failure.

The most common error made even by experienced pilots is losing flying speed on a turn which starts a side slip, and given sufficient height, terminates in a nose dive, or the more serious predicament, a spin. This mistake is often made under the stress of circumstances when engine failure calls forth extra effort on the part of the pilot to reach a certain landing spot. The trouble is nearly always incurred by turning too flatly until the wing drops and the machine side slips, generally in the effort to get into more suitable ground than that available straight ahead. This is always a dangerous manœuvre and in nine cases out of ten when smashes have resulted probably less damage would have been caused had the pilot kept his machine from turning and pancaked straight ahead. I have found that most of the later type machines can be stalled (*i.e.*, speed reduced well below flying speed) without any risk of side slipping, provided they are kept in a straight course and laterally level, as they will automatically drop the nose as soon as the speed becomes so low that the elevators have little or no effect. Most of the serious accidents start at a height insufficient for the machine to get out of its side slip before striking the ground. Others strike the ground at the later stage, usually a nose dive, but in some cases a spin. If sufficient height remains after the machine assumes a nose dive there is no reason why it should not be pulled out and a normal glide resumed, but in the other event, although it is possible to get out of a spin, it is far more difficult a proposition than the instinctive manœuvre of pulling up out of a nose dive.

A spin is the extraordinary turning movement that some machines only too readily take up after being stalled on a turn or being turned too flatly even with plenty of flying speed. This is due to the machine suddenly meeting the air a great deal out of the parallel with its longitudinal axis either through side slipping, skidding, or yawing in the air. Having had more than one involuntary spin, but having been fortunate enough to have sufficient height to get out again, I feel the matter is not to be treated too lightly. The position a machine assumes in a spin is a rapidly revolving side slip or a fairly steep spiral dive, with this rather serious drawback that the more one tries to pull it up by means of the elevator the faster it spins. No matter how high one is, if one persists in trying to pull it out in a normal way, it will remain out of control because the elevator has now become the rudder, and instead of pulling it out, increases the speed of turning. If the controls are abandoned the machine will come out of its own accord, but personally I have always found the best and quickest remedy for spins is to straighten the rudder and shove the joy-stick forward; a clean nose dive will then result out of which the machine can be pulled.

I think in the matter of spins, prevention is better than cure, and it is up to the designers to see that their machine is of the non-spinning type, as however clever and quick the pilot may be in applying his pet remedy, he may not have height enough to do so, and the results are usually disastrous.

The errors in judgment which are made in landing account for crashes galore, but these fortunately are usually a small matter compared to those mistakes made in the air, seldom resulting in more than a smashed landing chassis. Flying experience is the only remedy for this particular fault.

Landing with the wind will sometimes end in a crash through the machine over-running the limit of the landing ground; whilst landing side to wind will buckle wheels and wreck chassis. Neither of these troubles is always the direct fault of the pilot.

An easily distinguishable standard type wind-vane on every recognised landing ground would considerably lessen crashes from these causes.

Accidents directly due to faulty construction of the aeroplane are fortunately comparatively rare, as when they happen the results are so often fatal. They occur, however, even on standard types. In some cases the aeroplane is not entirely at fault, as in these days of heavy high speed efficient machines with so little head resistance and which attain colossal speeds on diving, it is such an easy matter for the pilot to increase the load beyond the highest factors of safety. One has only to consider the load on the wings of a machine dived at 160 m.p.h. when it is pulled out with a heavy hand.

Constructional failures of machines in the air can sometimes be traced to damage inflicted by imperfect landings, usually to the back part of the fuselage in the region of the tail skid. This gets overlooked and subsequently the tail gives way under any extra stress whilst flying.

I should like here to be permitted to make a suggestion for the consideration of our Chairman for what it is worth, *i.e.*, that a detailed record be kept of every engine failure, forced landing or accident of every kind and description that happens, at any rate, at all home stations. These records to be collected and classified so that valuable data may always be available. However, some such system as this may already be in operation.

"Training of Pilots."

I now come to a few points which might be brought forward from my experience with instruction of pilots. I think that a great deal of time and expense might be saved if some form of medical test were applied to prospective pilots, such as I understand is done in France, where the effect of sudden shocks upon the system of the candidate is recorded by mechanical means, and other tests are made which are supposed to give a fair indication at once of the medical fitness and the possession of the necessary qualities, such as nerve, judgment, and the presence of mind required for the making of a pilot.

There are many pupils on whom a lot of time and material has been wasted in the endeavour to make pilots of them who simply do not possess these ordinary qualities, and it is not until they have had smash after smash that it is discovered they simply have not got it in them. Now the French method should weed out the non-suitable candidate beforehand.

Personally I consider that the nearest equivalent to the art of flying is that of motor-car driving; a person who thoroughly understands and who can drive a car really well should possess the qualities required for piloting an aeroplane. General Brancker, in the paper he read a short time ago before the Society, mentioned a good horseman as the type possessing the necessary qualifications. I agree that good hands, a good head, steady nerves and judgment are essential qualities all of which should be found in a good motorist, with this advantage, that the good motorist is more likely to be naturally mechanical, a faculty inborn and not easily acquired, and so important in the matter of flying.

Time and material would be saved, in my opinion, if the modified "penguin" type of machine were more generally used for the very earliest training. I refer to the small-powered machine, incapable of leaving the ground, but designed solely for taxi-ing about the aerodrome, which was generally in vogue at the Bleriot Schools before the war. On this machine the pupil can be loosed off alone immediately after preliminary explanation with comparatively no risk, and at the same time he would get used to controlling his engine, have plenty of practice in the use of that important control, the rudder, and lastly, but not least, he would have to be left to his own resources, use a little initiative, and get used to the noise and wind from his motor. This type of machine might be modified

in such a way that the other controls might be brought to play an active part in piloting the "penguin" over the ground. The whole fuselage and wings might be supported independently of the landing chassis (or rather the rolling chassis) in a sort of gimballs, so that it could be banked and elevated by the control lever whilst running along or turning. I think an hour's taxiing on a machine of this type would, as a preliminary, be of more assistance than the same amount of dual control, as the pupil would know at least more about the use of his rudder.

The best type of aeroplane to use for instruction in actual flying and the question as to whether it should be stable or not is a very debatable point. I do think, however, that the less efficient within certain limits the early training machine is, the better and sounder will be the elementary knowledge and experience gained by the pupil. Such experience is likely to be very valuable when, later in his career, he is confronted with engine failures or similar predicaments, where his reserve of engine power will no longer cover up his multitude of sins in piloting. To illustrate this point, let us assume that there are two pilots, A and B. A has qualified for his Aero Club Certificate on a box-kite, *i.e.*, early Henry Farman type biplane, fitted with 50-h.p. Gnome. B gets his certificate on a much more powerful machine, one that can climb quicker, and can even be turned and climbed a bit at the same time. He knows this is so because he has done it on his last flight. But A finds that to get round really comfortably on his he feels compelled to drop the nose a little, as it feels a little sloppy otherwise. At a later date, on valuable service machines, both A and B have engine failures. A lands successfully, B crashes badly through turning too flatly. A has learnt from the beginning that he was always on the safe side in dropping her nose a bit on a turn; B always thought it unnecessary.

Personally I do not think that the stable machine is the best for training. If it is considered so on the score that once in the air it will look after itself and so reduce the chances of the pupil crashing, then we have only to assume for the sake of argument that a self-landing training machine has been devised that will automatically land itself correctly, do away with the smashes on landing, and ultimately, with a few more improvements, all the pupil need do would be just to sit still and take the air, as everything would be done for him, but after many hours of joy-riding on this super-school machine he would have learnt very little about piloting. For securing Aero Club Certificates for pupils at so much a head as a commercial proposition, this sort of machine might be excellent, but the unstable machine should be used as the basis of training to get the best results in the end.

I now come to another question, over which there is a deal of controversy. It is the use of instruments for training. I consider instruments as valuable accessories to any machine, but only under certain circumstances are they necessities, and in training they should not be regarded as indispensable. It is the wrong system, in my opinion, for the pupil to be made to rely on them too much. Although flying is largely a mechanical procedure, there is a tremendous lot of the personal sensation and feel that the pilot should acquire which, when once acquired, will take the place of practically any instrument devised. For instance, could an ice-skater learn to do the outside-edge merely by looking at a bubble of a spirit-level fixed in front of him? I should say no, but once he had acquired the feeling that he had correct balance, which only practice can give, he will make his sharp turn on the outside-edge at the correct angle better than any instrument could show him. Therefore I say let the pupil acquire without delay that naturally instinctive feeling so absolutely essential for a good pilot. Whilst he is taught to rely on his instrument too much to climb, turn, or even try and land, he will be long, if ever, in acquiring the art that will make him independent of instruments.

Personally I seldom use an instrument as an assistance to piloting. Do not

assume that I am sneering at instruments; in fact, as I have stated, there are times when they are a necessity. In fact, I am going to suggest that one more instrument be fitted as a standard equipment, an instrument to reduce the risks connected with flying in clouds. It may not generally be known that there have been such a large number of fatal accidents during the last three years entirely due to flying through clouds, and I consider this subject wants going into pretty carefully. The accidents to which I refer have not been questions of a want of height; the machines have become hopelessly out of control. I will give you an instance which happened to myself a few weeks ago in the West of England. You will then realise why I consider this is a serious matter requiring particular attention. I set out on a very cloudy, windy day to do a test climb to 10,000ft. on a late type two-seater. I had so often on previous occasions succeeded quite comfortably in reaching this height in spite of cloudy, overcast days by pushing up through the clouds, usually only a matter of a few minutes, into bright sunlight and the bluest of skies, and, after reaching the desired height, coming down again through the clouds, having flown by compass and time. On this particular day, however, the wind was very gusty, and on reaching 1,200ft. we got into dense rain cloud, but carried on to beyond 5,000ft., still in the cloud, when the compass apparently began to swing (really it's the machine that begins swinging, not the compass), and efforts to check the compass had the effect of causing it to swing more violently in the other direction. The air speed then rushed up far beyond normal flying speed; all efforts to pull her up checked her only slightly; then the rudder was tried, back went the air speed to zero; there was an unusual uncanny feeling of being detached from the machine, and I knew her to be literally tumbling about in the clouds. All efforts to settle down again to a straight flight seemed to be unavailing, until we emerged from the cloud very nearly upside down. Assuming control again was then an easy matter. This sort of thing has happened to me more than once, and, in the Flying Corps vernacular, " it puts the wind up you," and it has happened many times with other pilots. In some cases they emerge from the clouds in a spin, others are known in which the planes have collapsed under the strain of the sudden pull-up from the vertical nose-dive. A few days ago, a squadron commander told me that on one occasion when in France everything loose in his machine fell out whilst in a cloud. A week or so ago, on the South Coast, a machine disintegrated in a cloud and the main planes landed half a mile from the fuselage. From my own experience, this is a very unpleasant state of affairs, and in consequence I avoid clouds when possible. Let us try and examine the cause of this. First of all you must realise that in a cloud you see nothing whatever but your machine around you. There is no fixed point visible. The only means by which you can tell if you are flying in a straight course is by your compass and your air speed. The compass should give you your direction horizontally, your air speed your direction vertically. The first thing that happens, and very readily too, if windy and bumpy is that your compass card will begin to move slightly. It really appears to you that the compass was suddenly affected by the cloud, and you are still flying straight ahead. How often you hear a pilot say that as soon as he got into a cloud his compass started spinning. The moment the compass starts moving it requires extremely delicate ruddering to get it back to a steady position; in fact, one invariably over-corrects the compass movement and so the trouble begins. Once the compass starts on a good swing I have found it nearly an impossibility to get it steady again until out of the cloud. Before your compass starts to move your machine has already started to turn. You rudder the opposite way to check it, over-correct it, and turn sharper the other way on to a bank turn; then the nose drops and speed goes up. Pulling back your elevator lever has little or no effect, for if you are banked above an angle of 45 degrees the elevator becomes the rudder. All this occurs without the pilot being in the least bit aware of the position that his machine is taking relative to the ground. The instruments available are of little service once he loses his control.

Of what use is his air speed indicator to him indicating 150-m.p.h. if the machine is on a spinning spiral and he imagines that he is merely descending too fast on a steep, straight glide? He naturally tries to pull up, but with no effect. The bubble does not help him, as centrifugal force will send that anywhere. It may be argued that if a stable machine is left alone under these circumstances it will right itself eventually and assume a normal glide. It very likely would if the pilot could steel himself to let it entirely alone, but before it did so it would have to be left to do a sheer vertical nose-dive for some moments, and in these days of big weights and little head resistance one is liable to attempt to pull out too suddenly from the dangerous high rate of speed attained on this dive. What I want to see fitted is an instrument which will show a constant vertical or horizontal line and be independent of centrifugal force. I have no ideas upon the subject nor suggestions as to how this is to be brought about, unless something in the nature of a small gyroscope driven by an air-screw could be employed in some way to meet the requirements of flying in clouds, but until something is provided so that the pilot can see a fixed line, I think we shall continue to have accidents from this cause.

There are lots of other points that I should like to touch upon, but as my time is getting short I shall now deal with the subject of flying at great altitudes as I have found it. The most marked development in the modern machine is its extraordinary capacity for climbing to a great height in a short time. At the beginning of the war the average height flown on active service was 4,000-5,000ft., simply because few of the machines then in use with the impedimenta carried could get much higher. To-day a height of 20,000ft. is, I believe, on certain occasions reached, and it is fairly certain that if progress continues at its present rate, heights a great deal beyond this figure will be reached as a usual thing. These great altitudes bring forward many difficulties which will have to be seriously considered. The first trouble in the winter will be the extreme cold to which the occupants will be subjected unless they are protected by special cowling which will gather in the warmth given off from the engine. This, to a certain extent, is the natural advantage obtained in the tractor. The question of the difference in the comfort of machines in this respect was shown to me in a very marked manner last winter. I was testing the fall-off of engine power at a height on a tractor two-seater in which it was specially arranged that the warm air from the radiator and engine passed along the fuselage to the pilot and then to the passenger, and although at a height of over 21,000ft. with the thermometer below freezing at ground level, I did not suffer in the least from the cold, neither did my passenger who sat behind complain until we shut off to descend. As a contrast to this, a few days later I was on a single-seater scout at an altitude of 17,000ft., and although it was a tractor with a rotary motor, I suffered intensely from the cold, and became so numbed that my vitality must have been something akin to a dormouse under the snow, and, in spite of being well gloved, I had frostbitten finger tips, which pained for many days afterwards. Surely this is a very inefficient state for a pilot at the front to have to take on an air fight or other exacting work? Put two pilots up to a great altitude, one kept well warmed and comfortable, the other half dead with the cold, and it would be easy to surmise which would be most likely to do the best work.

I really believe it is more by accident than design that the pilot or passenger has benefited at all in the past from the heat of the engine, with the exception perhaps of the late S. F. Cody's machine. He purposely placed the radiator of his pusher in front of the pilot to keep him warm. I know from my experience when flying in France in the cold weather that the discomfort owing to the extreme cold became intense when flying only at 6,000ft. on a two or three hours' reconnaissance flight. This is a point to which designers should give attention, especially as machines are now easily capable of reaching great heights. During summer weather conditions would probably be tolerably comfortable, but in

winter it would be well nigh impossible unless better arrangements are generally made.

Cold also affects the motor pretty seriously. This is more noticeable with the water-cooled type. Unless some provision is made for blanketing the radiator surface at heights, it becomes far too cold for efficient running. Cases are known of the freezing of the water system on a descent from a great height, with pretty serious results to the motor, as well as the difficulty of getting the engine to run again efficiently through being too cold to effect a landing. In the future war machine the pilot must have a very wide range of control over the water-cooling system.

The next point for consideration is that of carburation. As the atmosphere decreases in density with the increase of height, so the motor gets less air, and unless the amount of petrol that gets to the engine is decreased in proportion to this decrease in the air, then the carburation goes all wrong through richness of mixture. Many machines with stationary type motors are fitted with what are called altitude correctors, an arrangement whereby the atmospheric pressure is decreased in the float chamber and so offering more resistance to the suction of the engine, reduces the amount of petrol flowing through the jets. As far as my experience goes, with this form of fuel regulator there is insufficient range of control, and the effect is very slight. I tried the other day a corrector whereby the jet apertures were controlled direct by the pilot, which is the best arrangement of this nature I have yet come across. As the altitude increases the jets are closed, so maintaining the engine revolutions. On a climb to 15,000ft. the engine only lost 25 revolutions per minute, principally because the mixture could be easily controlled and kept reasonably correct.

I will now touch lightly on effects that I have experienced on high flights. I have found the effect of high, *i.e.*, rarified, air to be felt slightly at about 10,000ft. increasing with the altitude. Breathing becomes affected, respiration shorter and quicker, there is a curious oppressive sensation and a bulging feeling in the head until the height of about 20,000ft. is reached. I am told by a medical friend who has made rather a study of the subject that there is always a risk of a sudden collapse, and oxygen should be used whether the aviator feels fit or not. Of course, the effect felt varies considerably with individuals, and with the state of one's health. About 18 months ago I suffered slightly with my heart, and found I could not get very high without feeling giddy, and after returning from a flight to 12,000ft. I had palpitation, which lasted until the following day. In consequence I had to abandon high flying until treatment got me fit again. This year I have made a number of high flights and have felt no ill effects whatsoever; in fact, I find the more one gets accustomed to going up high the less the effects are felt. I am told that this also is the case in mountaineering. I can remember the unpleasantness of my first flight to 15,000ft. It was very marked, especially the pain experienced in the drum of the ears on descending. The fact that a flight now to 21,000 or 22,000ft. does not have so much effect I put down entirely to acclimatisation. I use oxygen as a precaution when ascending beyond 20,000ft., for the previously mentioned reason. A small bottle is carried, fitted with a special reducing valve, which is fixed in the fuselage within easy reach of the hand. No special regulation is required, as it is set to pass only the necessary amount of gas into the face mask which acts as a mixing chamber, with its inlet and outlet air valve. The apparatus weighs 16lbs., and contains sufficient oxygen for one hour's continuous use. After reaching 20,000ft. I find it is only necessary to use the oxygen intermittently, and accordingly I simply hold the mask after turning on the gas over the mouth and nose and take a few breaths of it, perhaps every half minute. The effect to me is remarkable; most of the oppressive feeling vanishes, and, excepting for the unpleasant bulging feeling of the head, which you experience with a bad cold, the sensation is one of suddenly being again at ground level. The only after-effects upon landing from these high

altitudes are that you seem to acquire a pretty good thirst, due, I suppose, to the use of oxygen. If the speed of climb continues to improve at the rate it has for the past three years, it looks as though aviators will become subject to what is known as "Cassoon Disease," due, I am told, to the sudden reduction in atmospheric pressure, such as divers are subjected to when they come to the surface from a great depth, owing to the nitrogen which has been absorbed by the system, in proportion to the atmospheric density, forcing itself too rapidly at any lower pressure from the system.

There are many other points that I intended touching on in this paper, but I find that to do full justice to the subject it would occupy considerably more than the limited time at my disposal this evening if there is to be any discussion.

*** *The discussion on Capt. Hucks' paper will be found on page 426.*

THE TRAINING OF AERONAUTICAL ENGINEERS.

BY R. MULLINEUX WALMSLEY, D.SC., F.R.S.E., and

C. E. LARARD, M.I.C.E., M.I.M.E.

In winding up with the paper of this evening a highly-successful session of the Aëronautical Society of Great Britain, the authors desire to express their appreciation of the honour of being invited to conclude the series of lectures and papers delivered during the last six months. They hope they will not be misunderstood when they venture to affirm that, both in the planning of the course to cover practically every section and in the high level of excellence of the individual papers, the present necessities and the future of the science and practice of aeronautics have been admirably served. And to-night we reach as a fitting climax, because of its direct bearing on development in the immediate and still more in the distant future, the all-important subject of the education of our aeronautical engineers, that is, the education of those who are to follow in the footsteps of the readers of the preceding papers and their coadjutors and of those on whose fitness in the widest sense of the word the future of aeronautics in this country will depend.

In many quarters it is invariably the custom to overlook the fact that education is the most technical of all subjects, and requires as careful and laborious a study as any of those subjects which have preceded it in this course. That this is not generally recognised would be borne in upon anyone who would have the patience to read the proceedings and discussions of the numerous educational conferences which have been such a marked feature of the past winter. Education is "in the air," and has given rise to an almost endless succession of papers and speeches with little variation in the subject matter; the same things have been repeated *ad nauseam*, sometimes with very little difference in phraseology, while the number of really new ideas produced has been remarkably few. It is hoped, however, that as the authors are dealing with education for a new profession which itself is in a state of flux, they may, in what follows, contribute something of value to the general discussion. The following is, at any rate, a genuine attempt to place aeronautics on its educational side on a sound basis, so that, on this side, it may rank with the older well-established branches of engineering.

It is assumed that it is unnecessary to discuss the question as to the necessity for well-thought-out and co-ordinated schemes for the technical education of those who are to take charge in the near future of this important and scientific industry, that is, if this country is "to take the air and keep it," as has been recently well said by a well-known authority. If anything could have emphasised the point it would have been the far-reaching plans unfolded in the interesting paper of Mr. Holt Thomas and the discussion thereon barely a month ago in this series of lectures. Those plans take it for granted that a highly-trained staff of constructors and workmen will be available possessing a flexibility of mind based upon sound and varied knowledge which can only be acquired by such training as that which is dealt with in the present paper. The backbone of such a staff is an ample supply of aeronautical engineers who usually commence their professional work as technical assistants and who by habit and training are acquainted with the latest developments of the practical, scientific, and industrial problems which they are called upon to face. The greater part of the paper is therefore devoted to a discussion of the methods, as they appear to the authors, of training those who are in a position to devote not less than four years to a training

designed to fit them at the end of the training to commence practice as junior or senior technical assistants with every prospect of rising rapidly to higher, responsible positions. The needs of other classes less favourably placed and of those who are to fill lower positions are not lost sight of, and especially of that class of men already in the industry who *must* be given opportunities for keeping abreast of aeronautical developments as they proceed and of making up from time to time the ground which the strenuous nature and preoccupation of their daily work must cause them to lose.

The main object of the paper is the professional training of aeronautical engineers, but before this can be adequately dealt with it is necessary to consider the educational foundation upon which, in the opinion of the authors, this training should be based, for one outcome of the past winter's discussions has been to bring into prominence the chaotic nature of much of the general education of the youth of this country.

Preliminary Education.

The preliminary education of students who desire to be trained as aeronautical engineers should, in the opinion of the authors, be a good secondary school education, in which the student has been taught, through the medium of the proper subjects of such an education, to think and to weigh evidence If this end be attained, it is far more important than any workshop or other quasi-technical training that can be obtained in a secondary school, especially if, as is often the case, such training is given at the cost of the more essential subjects of a secondary school education. The claims of science and scientific method to be included in such a curriculum have now been practically conceded, even by many who have been for long years staunch upholders of the claims of the "humanities," to dominate the time-table to the exclusion of nearly everything else but mathematics. A good grounding in mathematics is, of course, of prime importance to the future engineer, and his curriculum must also include a good working knowledge of not less than one modern language, in view of the large amount of scientific and technical literature published in foreign journals and by foreign societies, as well as of the fact that during the next 50 years an enormous amount of engineering work will be required in countries in which English is not the vernacular, and that engineering industrial developments will be the common heritage for all time of all the civilised countries of the world.

For many years science was practically tabooed in the secondary schools on the plea that there was no room for it in a time-table in which even modern languages had not a very conspicuous share. What was still worse was that the best and brightest boys, or at any rate those developing the greatest promise, were never given a chance of showing their aptitude for a scientific training, but at an early period of their school career were set to specialised studies in the humanities, including an excessive amount of time devoted to Latin and Greek, so that in due course a small minority of them might bring renown and distinction to the school by winning University scholarships. Meanwhile, as a sop to public opinion, a "modern" side was formed, to which only the conspicuous failures were drafted.

These evil methods still persist in certain schools, but other dangers have more recently begun to show themselves in quite another direction. There is now a danger that science may not be adequately dealt with because of the desire to include "engineering" subjects in the time-table. The prospective engineer should first be well educated, in the proper sense of the word, in mathematics, in the humanities (but including English and modern languages), and in science, his education in science being with a view to training in scientific method rather than to the handling of a large number of subjects. An education which adequately covers this range will certainly fill the limited time of the average boy

and will satisfy the ambition of the most voracious schoolboy. The intensive study of the sciences on which all engineering is based as well as the special " engineering " subjects which, of late years, are becoming fashionable in certain schools will be far more advantageously and economically postponed until the time when real professional training is undertaken.

If the student has received a good education, in the sense set forth, he should be ready to start his engineering training by the time he reaches the age of 17 in the case of the best students, and at 18 in the case of students whose development is not so well forward. From the engineering point of view, the retention of a youth at a secondary school beyond these ages for the purpose of taking so-called " engineering subjects " constitutes a very serious loss of time, in view of the fact that such subjects cannot be properly and economically taught, except in correlation with a systematic and well-organised complete engineering course, and further, such work cannot in general be effective when undertaken by any but a fully-qualified engineering teacher. It is obvious that when subsequently attending a complete engineering course at a technical college the student will receive in fuller and sounder measure such instruction as part of the regular course covering all, and more than all, he could have possibly received in a secondary school; and moreover, there is a real danger, which has been actually experienced, that certain methods and ideas included in certain school courses may have to be corrected, if not eradicated.

Technical Training.

Passing now from the preliminary but important school work to the subsequent professional training, there is much division of opinion among engineers and engineering teachers as to the position which workshop training should occupy in relation to the more purely technical training of the student. Many engineers and engineering teachers are of opinion that practical experience on the works or in the factory of an engineer should be gained *before* taking up an engineering course at a technical college. They argue

(1) That works experience is necessary to enable the student to take full advantage and realise the importance of his studies at an engineering college.

(2) That it does not follow that a man who has first passed through the technical college will necessarily make a successful engineer, the works training under practical conditions being, it is asserted, the best test for his fitness.

(3) That the student trained in the technical college does not, after his college course, take kindly to the manual labour in the shops necessary to complete his experience, and that when he passes into the works as a workman he finds a greater difficulty in raising himself afterwards to a position of responsibility than one who has obtained works experience first and technical training afterwards.

There are, however, other well-known engineers (and engineering teachers) who are of opinion that the above views are too often based on an imperfect knowledge of what a really good college course in a modern and up-to-date technical college can accomplish, especially if it be combined with practical experience in works judiciously introduced at the proper period when the early stages of engineering training have been sufficiently developed to prepare the student to assimilate the experience of a commercial workshop more rapidly. Such systems of engineering education are now known as " Sandwich " systems, and as long ago as 1903 a pioneer system of this type was adopted at the Northampton Polytechnic Institute, after a careful and exhaustive inquiry into the details and the results of the various systems of engineering education then in being in the chief countries turning out good engineering work. In organising,

planning, and carrying out the necessary instruction courses, the Principal, who introduced the system (?), has received the loyal co-operation of his colleagues on the staff; and it is to this co-operation that the success attained is due, and what immediately follows is based upon the experience so gained, and not upon mere educational theory.

It is therefore submitted that engineering training in a well-staffed and well-equipped technical college should be started directly the student leaves the secondary school, and that for this purpose, as college sessions begin at the end of September, he should leave school not at Christmas or Easter, but only at the end of the summer term in July. As already mentioned, it is considered in some quarters desirable that a student, on leaving the secondary school, should go straight into a works for, say, a year, in order that it may be ascertained whether he has any aptitude for engineering training. There is, however, a good deal of evidence to support the opinion that aptitude for engineering training can be more readily and quickly tested in a well-organised technical college, staffed with men who have been through the works, than it can in the works. The question is, to some extent, one of "lost time." In the works weeks, if not months, must inevitably be lost before the student begins to understand in any educational sense what is going on around him. On the other hand, if he goes straight to the technical college his education is continued without a break being very apparent. In fact, one of the difficulties in a modern technical college is to make the first-year student realise that he is no longer at school, and that his professional work has commenced, and further that the greater freedom of college conditions which he is quick to take advantage of is accompanied by a correspondingly greater amount of individual responsibility.

For admission to the college the student should be required to pass an entrance examination if he has not, as he should have done, passed an examination qualifying for admission to a University before leaving the secondary school. But such an entrance examination and even the University matriculation should be regarded as merely indicative, and not as the actual test of the candidate's aptitude for an engineering career. The real entrance examination in a technical college is the work of the first term, or of the first session, and during one or other of these periods the trained staff is capable of answering very definitely the question "Should the engineering training be continued?" If the answer be in the negative, the training should be dropped not later than the end of the first year, and the student should devote his energies to some other training more in accordance with his natural bent. If, however, it is decided that failure in the first year is due merely to a student, as is sometimes the case, failing to realise his responsibilities and opportunities, he should be given another opportunity of facing the first year's work.

As to the kind of training specially suitable for aeronautical engineers, the authors make no apology for basing the schemes which they put forward upon the experience of the teaching of aeronautics gained at the Northampton Polytechnic Institute, at which pioneer courses were started in September, 1909. This experience is combined with their experience in the successful training of engineers in other branches of engineering which has been referred to above. Detailed syllabuses and time-tables are set forth in Appendices I. and II., and in the following remarks reference is made to these.

No distinction is made in what follows between the professional training of engineers in the Universities and in technical institutes. In both cases the training is essentially the same for all students who are commencing their training and for all students up to the standard of a first, including an honours, degree at the University. As a matter of fact, throughout the country the association of the larger technical institutes with the Universities is very close indeed. In London the principal teachers of engineering, in the more important of the polytechnics

which prominently deal with engineering, are members of the Boards of Studies in Engineering at the University, and these institutions are recognised under the University Statutes for training internal students. In Manchester the association is even closer, the Municipal School of Technology being a part of the University for all effective purposes. Similar associations exist elsewhere, but in accordance with our time-honoured English plan of doing these things, they differ in detail in almost every instance.

The chief function of a technical college in this connection is obviously to train real engineers and not merely to train University graduates, but if the University curriculum is properly drafted, the two curricula cannot differ very much up to the honours standard of a first degree. Where the University work in the future should be most differentiated from that of the technical colleges should be in the greater leisure and opportunities for post-graduate research, though, as is well known, such research is by no means neglected at the foremost technical colleges, and the point is dealt with later. In this connection a cordial vote of welcome may be given to the munificence of M. Zahkaroff on his gift, through the British Government, of £25,000 to the University of London for the foundation of a chair in aeronautics.

For the purposes of this paper it will be convenient in taking up the details to separate that part of the college training which is not specially aeronautical, but is common to other branches of engineering, from the part which is more particularly required by aeronautical engineers, and which would not, as a rule, be taken by other engineering students.

THE NECESSARY COLLEGE TRAINING NOT SPECIALLY AERONAUTICAL.

It is not clearly understood by some aeronautical engineers and by many others that a sound preliminary training in general engineering principles similar to that outlined in the Northampton Institute syllabuses for first and second-year day students is required before any reasonable progress can be made with the higher studies in aeronautics, or even of any studies in aeronautics distinctively so called; and further, that concurrently with the specialised instruction in aeronautical engineering following such a preliminary training much higher instruction work in mechanical engineering is required. For instance, it is essential that the student's mathematical studies shall continue through each year while attending the technical college, the standard of knowledge attained being the same as for other departments of engineering, and including a good working knowledge of the differential and integral calculus and of higher mathematics generally.

The course outlined is intended to cover four ordinary educational sessions from the beginning of October in the first year to July in the fourth year. In this period the second and third summers, from April to October, are to be spent in commercial workshops, with only such works holidays as fall within those months.

The first session's work is based upon the assumption that the prospective student has attained the well-known standard set for the matriculation at the University of London, either in a general examination or through the senior school examination. This ensures a fair knowledge of elementary mathematics, the power of expression in English, a knowledge of one language, and some knowledge of a science from which it is hoped that the student has acquired some idea of scientific methods. So as not to exclude latent engineering talent, however, some students are admitted on a designedly lower entrance standard in view of the rigorous application of the plan set forth above of treating the whole of the first year's work as an extended entrance examination.

The first session's work is devoted to a thorough grounding in mathematics, pure and applied, physics and chemistry, with the addition of engineering drawing

and elementary engineering design, such as is required by all engineers, civil or mechanical. It is during this period that the ineligibles and the slackers are weeded out, rather than at the entrance examination, at which some of the students on the border line for passing can therefore be admitted as probationers, to give them a chance of showing whether they are likely to be successful in the later courses.

Special technological training begins with the second session which, as already explained, is a two-term session, at the end of which works experience, lasting from Easter to October, is to be started. Distinct specialisation begins from the time the student goes into the works at Easter of this second session, and from that time onward the aim is to train him very specially in some main branch of engineering, in this case in aeronautics, whilst giving him a good knowledge in other branches. It must be understood that in these later years, notwithstanding early promise, a particular student may show that he is unable to assimilate the highest training offered. In such a case it will be advantageous to transfer the student to the works when he has reached the limit of the college training he is capable of absorbing, and which will undoubtedly be a great advantage to him in his subsequent work.

Time-tables for these two sessions of general training are given in Appendix II., but as detailed syllabuses are not given in Appendix I. a few remarks may be made upon the scope of the work in the various subjects at this stage.

In mathematics the aim throughout is to train and develop the student's mathematical faculty (which if poor or entirely lacking will disqualify him from dealing with advanced problems in engineering) in such a way that ordinary mathematical processes in algebra, geometry, trigonometry, and the differential and integral calculus become *working tools,* to be almost unconsciously used as a matter of habit.

The physics in the preliminary course is treated with the distinct purpose of qualifying the student specialising in aeronautics later on to deal readily *inter alia* with the theory and practical calculations of aero-engine cycles, to grip the principles and details of magneto ignition and other electrical devices carried by aircraft, and to understand their observational equipment, etc., etc.

The special study of aero engines must obviously be preceded by an outline study of heat engines generally and of heat engine cycles, particularly those dealing with internal combustion engines. The fundamental principles of hydraulics and pneumatics, as well as of meteorology, call for special study during the preliminary work at a properly-organised course of instruction in aeronautics.

During this preliminary course the student also acquires a knowledge of the principles of chemistry sufficient, at least, to enable him to deal effectively, when taking the higher and more specialised work of the advanced course, with the necessary calculations on the combustion of fuel, and particularly of gaseous fuels. His laboratory training includes the use of gas analysis apparatus and the analyses of exhaust gases from internal combustion engines.

His preliminary studies of engineering materials, from the chemical as well as the mechanical point of view, are designed to enable him to understand the importance of a chemical analysis of the material and of the influence, beneficial or deleterious, of small percentages of certain chemical elements on the properties of the material for resisting static or kinetic stress and on the elasticity and resilience of the material.

Aeronautical drawing and design obviously cannot be properly dealt with until the student has first mastered the elements of geometrical and mechanical drawing and made himself familiar with drawing office methods. This preliminary training, therefore, is dealt with before attempting any specialisation in aeronautics. In the courses and time-tables given in Appendix II. provision is made during the first session for giving a thorough grounding in these essentials,

and it is unnecessary in a paper of this kind to give a syllabus of the kind of preliminary work in this connection. It is too well known to require specification.

And last, but not by any means of least importance, some attention must be given to the business or commercial side of engineering. How often has it been said by the employer, "Yes, So-and-so is excellently trained in engineering theory and is even fairly good as a designer, but in business matters he is a baby, and not to be compared with men in my works who, though they may not be good at theory, know and can deal with the bearing of their work in relation to £ s. d. It is a pity that the technical schools cannot give some attention to their work in its business aspect." Even in the preliminary work, therefore, this aspect must not be overlooked, though its formal treatment belongs more properly to the specialised work of the third and fourth sessions.

THE COLLEGE TRAINING SPECIALLY AERONAUTICAL.

This special training, as already explained, is dealt with in the third and fourth sessions' work for which the time-tables will be found in Appendix II. For the special subjects appearing in these time-tables detailed syllabuses will be found in Appendix I., but in view of the relevancy of these subjects a few general remarks will not be inappropriate here.

The *theory of machines and of mechanism*, to lead up to which a good knowledge of mechanics is provided in the first two years, form a special feature of the advanced work in direct relationship to many practical problems, such, for example, as the inertia effects of moving masses, whether free or constrained, as in the primary and secondary balancing of engine parts. In this connection the gyroscopic effects on the machine, due to rotation or turning, in the engines, mechanism or propeller, and also the machine itself, are fully dealt with.

The *advanced design work* for aircraft prime movers necessarily involves the advanced theory of heat engines, modified by practical considerations and experience, together with mechanical design based on a full knowledge of the strength, elasticity, fatigue and durability of materials.

More advanced work than can well be included in preliminary courses is therefore given on the strength, elasticity and fatigue of materials, and proceeds concurrently with specialised instruction work in other subjects of aeronautical engineering. The effects of fatigue on the various parts of an aeroplane structure due to repetitions and variations of stresses, does not yet appear to have attracted serious attention in connection with aeroplane work, and no doubt some disastrous failures of machines are due to such effects.

The *advanced drawing office work* in aeronautics consists in applying the general principles and experimental data for aircraft to the design of the details, the chief parts of the machine, and finally the full structure, with provision for more advanced design for students who wish to specialise in some particular section of the work, *e.g.*, engines, or propellers, or fuselage.

Very little has as yet been properly standardised for the constructive details, or even for the full machine, and each manufacturing firm is to some extent a law unto itself. This is of course inevitable from the nature of the case. Only a very limited amount of standardisation would at the present time be of any value, for the design work for aeroplanes is in such a state of flux that parts have to be designed and re-designed over and over again before anything final for a particular machine can be arrived at. After each design it becomes necessary in many cases to subject the built-up product to experiment or test in the laboratory and workshop, with the result that more often than not re-design is necessary. For example, unexpected weaknesses may be revealed under test in some part of a joint or clip, so serious as to render the greater part of the design useless until the defect is remedied by a modification of the whole design.

This being the present state of things in relation to aeronautical design it follows that at the technical college testing in many cases should follow preliminary designs so as to arrive at a design distinctly good for the purpose it is intended to serve.

Too much must not be expected from the trained product of a technical college in this respect. As remarked more than once the profession of aeronautics is a new one and at present subject to ever varying change. A vast amount of experimental work has yet to be done, new ideas which are at present only dimly emerging have yet to be tried, and new materials and combinations of materials have yet to be put to the test of actual utilisation. The manufacturer must be satisfied if the technical college gives him a trained intelligence under the guidance of a sound common sense, in short, a man who is well versed in the fundamental principles of aeronautics and who can apply his knowledge to a reasonable extent in both experiment and design.

Laboratory work, especially of such a highly technical type as is necessary in the education of aeronautical engineers, does not lend itself in the same way as lecture work to the precise synoptical specification of a formal syllabus, and therefore no laboratory syllabus is set out in Appendix I. The scope and range of the work recommended will be better gathered from the following remarks.

In attempting, however, to give even an outline of some of the essential experimental or laboratory work one is brought face to face with the kind of difficulty necessarily experienced in dealing with a new industry or applied science and in endeavouring to organise the educational work relating thereto so as to give both the systematic instruction in the fundamental principles underlying that industry and to stimulate ideas for future developments.

Seldom in any branch of engineering has a new profession been created in so short a time and never under such dramatic circumstances. Aeronautical engineering as a profession has been brought into prominence and practically created by the great issues at stake in the disastrous conflict still raging. Before the war aeronautics was little more than a sport or pastime, it has now definitely taken its place and will in future rank as a great profession.

The laboratory work specially aeronautical in character should consist of the testing of:—

(*a*) Special materials used in aeronautical construction for strength, elasticity, hardness and fatigue.
(*b*) Fastenings, attachments, shock absorbers and combinations of parts.
(*c*) Models of different forms in a current of air at different velocities.
(*d*) Propeller models in translational as well as for rotary motion.
(*e*) Aero engines.

Much of the laboratory instruction undertaken at the technical college will thus necessarily be of the nature of research, although a good grounding will have to be given in the more usual work dealing with the testing of the strength and properties of material and with the testing of engines generally.

In the testing of materials now commonly used in aeroplane construction, new materials will from time to time have to be tried. In addition to the testing of cables, strainers, and struts and ties, experiments will have to be made on simple and complicated steel and other plate and bolt attachments for building up the light skeleton aeroplane fuselage of wood and metal. The materials testing laboratory for aeronautical engineering students will thus become, at any rate for some years, primarily a research laboratory.

Taking timber, for example, as used in aeroplane building, it might be thought that sufficient experimental data had been accumulated regarding spruce and other woods. But this is not the case, though probably there is much more data available than has been published. Much of the requisite experimental work

remains yet to be done in the determination, *inter alia*, of the effect, on the strength and elasticity of the material, of defects inherent in the natural growth of the timber.

It has been shown, for instance, that the useful strength of timber is due to that part of its morphological structure known as "mechanical tissue," and experiments have been made which seem to point to the conclusion that this tissue is actually stronger than steel, but of course it is diffused or spread out by other vegetable or cell structures of negligible strength. Here alone is a vast field for research. Can this mechanical tissue be concentrated into close bundles giving relatively enormous strength, and if so, will the density of the material be then so high as to prohibit its use? Obviously the density, or mass per unit volume, is a factor which cannot be neglected in aeroplane work. Some woods are too heavy to be used at present. One of the author's assistants in a research carried out in the Materials Laboratory at the Northampton Polytechnic Institute, showed, for example, that the compressive strength of different kinds of timber was a linear function of the density—a very important result. Other properties, such as tenacity, deflection, and in the case of struts, buckling, may also be a function of or dependent on the density. Then investigations are required on the strength and elasticity of timber, for the effects of knots and gum veins, the straightness or otherwise of the grain, the closeness of the mechanical tissues, the direction of the grain with respect to the plane of flexure. The effects of water absorbed during variable conditions of climate, *e.g.*, snow, rain, or clouds, and the hygrometric state of the air on the material of the timber have yet to be investigated.

There is further the necessity of testing plate and other attachments, by means of which the timber parts are secured together to form the skeleton structure of the fuselage, and in this connection those who have had to deal with the design and testing of these plate attachments for wood members know how very difficult it is to secure so firm a holding on such a light wood as spruce as to stand a reasonable working stress. Here again is a valuable field for laboratory work.

Turning to another matter, a very prominent part of the laboratory equipment must consist of a wind tunnel, with its motor driven propeller and provided with indicating and recording instruments for experiments and research on models of planes and wing surfaces or structures, on models or parts of aeroplane structures, etc. Part of the wind tunnel should be arranged so that the air or stream line flowing past a plane model or solid obstacle can be made visible and the resistance measured. That is, the experimental work should be qualitative as well as quantitative in the determination of lift and drift for surfaces of varying forms and aspect ratios and the resistance of models of aeroplane parts which are required to cut through the air. Indications of best sections and forms can in this way be obtained and provisional designs satisfactorily adjusted.

Workshop and Practical Work.—In the general scheme the bulk of the workshop and practical work is to be taken in actual and not in the college workshops during the two summer periods, referred to on page 407, and if in particular cases additional work of this kind is deemed to be necessary it would naturally fall to be taken at the end of the fourth session.

In aeronautical engineering there is one kind of practical work, namely, aviation or flying, which cannot under present conditions be included in the course at a technical college, but in regard to which the student should acquire some definite knowledge. While, therefore, the educational course cannot deal with flying *qua* flying, yet it will be of advantage to arrange for periodical visits of the students to the flying grounds and even to provide for some lectures given by an engineer-aviator on the behaviour of aeroplanes under practical conditions of flight. In addition, as in other branches of engineering education, visits should be paid to works in which aeroplanes are in various stages of construction. In

this way the student will be stimulated in his studies and will gain some insight into the every-day work of the aeronautical engineer.

It may even be found to be possible in the case of the senior students to arrange for trial flights so as to familiarise them still further with the behaviour of the machines upon the theory and designing of which so much of their time will have been spent.

The case is analogous to that of the student apprentices of locomotive engineering or of marine engineering, who are always ambitious to take part in a trial run or a trial trip. Similarly, it is natural to suppose that a trial flight (not as pilot) will have attractions as well as being practically valuable for the student apprentice who is approaching the end of his college training in aeronautics.

Perhaps even the day is not far distant when the requirements of education and research will justify an experimental aerodrome, laboratory and flying ground for experiments on a larger scale and of much wider applications than is possible at the present time. The chief obstacle at the present time is the necessarily heavy expenditure.

SPECIAL AND EVENING INSTRUCTION.

No scheme for the education of aeronautical engineers can be considered complete at the present time which fails to take into account the general as well as the specialised instruction required by the very large number of engineers and engineering students who for various reasons are quite unable to attend aeronautical courses in an engineering day college.

These men may for the most part be placed in one or other of the following classes or categories :—

(1.) The rank and file of apprentices, learners, improvers and journeymen, the best of whom may subsequently rise to class 2 and who are employed or employable in the shops and drawing offices.

(2.) Trained engineers, civil, mechanical, electrical, or military, who have already received in varying degrees of proficiency the educational training qualifying them for the particular branch of engineering in which they are or have been employed and who from the force of circumstances have changed over or intend changing over to aeronautical engineering. From the necessities of the case it goes without saying that, up to the present, the best design and constructive work in aeronautics has been done by men who received their technical education in one or other of the older branches of engineering before aeronautical work developed and this training has proved invaluable to them as a solid foundation for the specialised work of aeronautics. For some time to come the ranks of the aeronautical engineer will still be recruited from men already possessing these solid qualifications, the more ambitious of whom will be eager to supplement their training and experience by special study of the new science.

For the first-named or apprentice category an excellent start, well calculated to arouse the interest and stimulate the ambition of many who are only too much inclined to waste their leisure time, has been made in the series of works lectures which have been inaugurated by the Society during the present session and which it is proposed to extend in the coming autumn and winter. Further reference is made to this work later.

It is not likely, however, to be overlooked that if substantial educational benefit is to follow from these lectures, regular and systematic courses must be attended in a well organised technical college. Such students will have to face much preliminary work in mathematics and general engineering theory, in drawing office and laboratory work before any real progress can be made by attendance at classes dealing specially with aeronautical engineering. Indeed, it will be

found in this connection as with other branches of engineering that a very large number, probably the majority, will never effectively get beyond the mere elements of workshop calculations and drawing. Many are called but few chosen. Aeronautical engineering, like other professions, requires its "hewers of wood and drawers of water." Notwithstanding, it is advisable to arrange lecture courses and practical work of an elementary character in aeronautics specially suitable to the requirements of the man who will join the artisan section of this important industry. He will be a far better workman because of a knowledge of workshop arithmetic and drawing, supplemented by simple laboratory experiments and by information gained whilst attending aeronautical lectures sufficient to arouse and maintain a living interest in his daily work. Some there will be who will rise through and overcome every difficulty and disability and to these such a preliminary course of work will not only present no insurmountable obstacle, but by the facilities available will help them on their road to higher things. Such men will finally show that they are capable of successfully grappling with the higher studies requiring the more complete knowledge. A few will go beyond and raise themselves from the workman grade to that of the professional man.

The courses arranged will be progressive, the more elementary being suitable for the machine and bench hand and the higher for the leading hands, shop foremen and others.

An important question is the period of the day when such courses should be given. Up to a comparatively recent date it was assumed, almost without question, that the only time available was the evening after a full day's work had been done in the commercial workshop. For those who have attained to the position of leading hand or shop foreman it is probable that this is still the only available time. But for the juniors who have only recently left school and who are yet in their teens, it is now widely recognised that such evening work involves a strain to which the majority of youths whose physical development is still immature should not be subjected and the existence of which goes far to neutralise the educational benefit which should result. For these students "time off" during working hours is absolutely necessary, and it is indeed probable that, in the near future, legislation may require that such time off shall be given. Such proposals raise social and other questions which it would be outside the limits of this paper to discuss, but, from the educational standpoint only, the definite opinion may be expressed that compulsory attendance of the juniors in engineering works at afternoon classes should lead to valuable educational results.

At this stage it is relevant to speak more fully of the splendid work done by the Aëronautical Society in its students' section in the series of ten lectures delivered during the past six months at the Hendon centre and afterwards repeated at Cardiff. No excuse is needed for mentioning so recent a departure, for it is very probable that there are many, even members of the Society, who have not realised the educational significance of this work.

The lectures at Hendon were delivered in a conveniently-placed public hall to the employees in the numerous and important works and aerodromes congregated in the neighbourhood. No charge was made for admission. In each case the lectures were given by well-known experts in the particular subjects dealt with, and usually a well-known member of the Society presided, our worthy President being in the chair at the first meeting.

Such a series of lectures repeated throughout the country in the various industrial centres devoted to aeronautics may well be regarded as having two principal objectives, though their influence will, it is certain, be much wider. The first of these objectives is the building up of a strong students' section for the Society itself. These students' sections, in more than one of the professional societies, have been a distinct success. They are essentially democratic, being

organised and conducted under the ægis of the Society by the students themselves. Ordinary members of the Society are not allowed to attend the meetings with the one exception that at each meeting the chair may be, and usually is, at the invitation of the students, taken by a prominent member of the Society. The idea is that the meeting room should not be filled with expert critics before whom the students would be unwilling to air their original, if somewhat crude, notions. As a rule a student who has had special connection with a definite part of the subject is put up to read a paper. Other students diligently get up as much as they can of the subject in the time available and mercilessly criticise their colleague. The chairman acts as a moderator and, whilst not sparing in his criticism, it is hoped, and, as a matter of fact, as a rule, it usually so happens that he criticises with the necessary courtesy and consideration.

The other object which the lectures at Hendon and similar lectures may be regarded as serving is the popularising and stimulation of further study amongst those actually engaged in the lower ranks of the industry. Incidentally such lectures must lead to the desire on the part of the more ambitious, who, we may hope, in this industry will be the majority, to systematise their knowledge by attendance at well-organised technical courses. Should this object be attained, nothing but good can result to the industry as a whole.

One need not dwell at length upon other and obvious advantages in such courses of lectures, not the least of which is the personal inter-mingling of so many young men with similar aims who will be the standard-bearers as well as the chiefs and captains of industry in the not very distant future. An intimate knowledge of those who are to be either directly associated with oneself or to be one's competitors is not the least effective factor in a successful career in any large industry such as that which we are considering.

Turning now to the second category for whom special educational facilities should be provided, aeronautical lectures, laboratory, and drawing office classes dealing with the subject matter outlined in the syllabuses on pages 416-17 will be the first essential and will meet the requirements in many cases.

For many such students, however, still more specialised instruction in aeronautical engineering is desirable, and indeed necessary. For this purpose occasional or visiting lecturers or instructors with special qualifications should be appointed both for day and evening work. These lecturers should be intimately connected with the design and construction of aeroplanes as part of their regular daily work and should be men who have themselves received a sound and thorough technical training in the advanced as well as the more elementary fundamental principles of engineering theory. In other words, they should be highly trained on the theoretical side as well as on the practical side. Moreover, an endeavour should be made to select men with a special knowledge and skill in particular branches of aeronautics, and special lecture or instruction courses should be arranged accordingly. The following are some of the subjects in which such instructors may be required for lecture and design classes :—

(1.) General aeronautical engineering.
(2.) Fuselage design.
(3.) Aero engines.
(4.) Aero propellers.
(5.) Magneto-electric ignition and other auxiliary electrical devices.
(6.) Meteorology and the meteorological conditions during flight.
(7.) The behaviour of aeroplanes in the air and aircraft performance treated by an expert engineer-aviator.
(8.) Dirigibles and lighter-than-air machines.

The above are suggestions for consideration based on some experience, with successful results, in providing special lectures with expert instructors in specific subjects. It will be well understood, however, that the highly special work, some

of which is outlined, cannot be fully taken advantage of by individual students until the elementary and the higher general engineering and aeronautical work have been fully assimilated. It has become too much the fashion in some quarters to advertise and give special lectures in aeronautics without realising that such lectures are not likely to be of practical value until they are developed into special treatment on the drawing board, the laboratory, and the shops.

For the best results the specialised lecturer in some of the above subjects should also conduct the design or drawing office class for his special section of the work, or failing this, the class should be taken by another properly qualified designer with intimate knowledge of his subject.

RESEARCH ASSISTANTS AND SCHOLARSHIPS.

There remain two other sections of the subject to which it is important that some reference should be made, namely: (i) research and (ii) scholarships, and these may well be taken together. It has already been pointed out that much of the laboratory work in aeronautics at the technical colleges will necessarily be of the nature of research work, and in order that this work may be efficiently carried out it is essential that the ordinary teaching staffs should be strengthened by the appointment of

(*a*) Research assistants.
(*b*) The establishment of senior scholarships and research studentships.
(*c*) The establishment of junior scholarships.

on the lines set forth in a Report issued last year by the Committee of the Privy Council for Scientific and Industrial Research, now the Department of Scientific and Industrial Research.

These additional assistants should act under the direction of the professor or head of department, who would suggest lines of research in addition to those suggested by the assistants themselves. Suggestions for researches from other quarters such as the Aëronautical Society should also receive every consideration, and, where funds are available or can be provided, a serious effort should be made to enlist the direct interest and support of the local education authorities.

In view of the fact that the research assistant would be appointed to work at a particular college it is recommended that as the success of the work would depend very much upon the qualifications and personality of the assistant, his selection should be made by the technical college concerned and on no account by competitive examinations. The donors of any funds for providing the research assistant would, of course, be consulted.

A suitable research assistant having been appointed, he should give his whole time to the work, but in the general interest of aeronautics it should be possible for his services to be utilised for teaching work in aeronautics for a certain number of hours during the teaching session. This arrangement would be advantageous in giving the assistant a very vital grip of the general aspects of his subject, and would be specially useful to him as well as to the teaching profession if he intended later to become a teacher of aeronautical engineering.

It is, of course, assumed that the assistant appointed would be well qualified for research work, and that he would not necessarily require any considerable proportion of the time of the head of the department, otherwise his appointment would be of doubtful value.

With respect to (*b*), it is as well to emphasise the difference between research which might be done by technical students and research which should be done by a research assistant, the former being of the nature of training in methods of research rather than the actual undertaking of new work, which would be the proper function of the research assistant. It is therefore desirable that, in view of the importance of their other work, senior students during the last years of an

ordinary engineering course should be trained more in methods of research rather than in actual researches for publication occupying a disproportionate volume of their time.

It is also recommended that selected students who have completed an ordinary or other approved course of training should be appointed "research students" with a small maintenance allowance, less than that allotted to research assistants, the necessary funds to be provided from the same source as the funds for research assistants. In course of time this procedure may prove of material assistance in the selection of suitable research assistants.

There will be no difficulty in a fair number of subjects for research being suggested in any large engineering department, and researches may also be suggested by manufacturers. With regard, however, to the latter source of inspiration, it is recognised that engineering manufacturers in both small and large ways of business must have a number of problems from time to time requiring scientific investigation, but whether these manufacturers would be willing to submit to the publicity consequent upon the acceptance of public money for the purpose of the carrying out of an investigation appears to be very doubtful. In other words, manufacturers may be expected to be willing to suggest and assist in a research provided they can reap the sole benefits of the results, but may not be so willing if it be a condition that the results are to be publicly published and placed at the disposal of their trade rivals.

With respect to (*c*), junior scholarships should be awarded to selected evening students who have, with marked success, attended evening classes or courses for, say, two or three sessions. These scholarships, with a small maintenance allowance, will permit of their holders to attend a full engineering course in the day time.

CONCLUSION.

The above does not by any means exhaust the subject of the training of aeronautical engineers, but the authors trust that they have dealt sufficiently with the main lines to stimulate discussion and to bring this important aspect of the subject in precise form prominently before their engineering colleagues.

They hope that the next and subsequent sessions of the Universities and the technical colleges will witness a great development all over the country in the direction of providing sound instruction courses in aeronautical engineering.

If this hope be realised the time spent by the authors in the preparation of this paper will not have been spent in vain.

APPENDIX I.

SPECIAL SYLLABUSES.

I.—GENERAL AERONAUTICS.

(PRINCIPLES AND MACHINES.)

The Atmosphere—properties. Air at rest and in motion. Meteorology.

Definitions and first principles.

Action of air current on plane and curved surfaces. Mass, centre of gravity, centre of pressure, lift, thrust, etc. Inertia.

Resistance to motion—wing, body and fuselage parts. Stream line flow.

The methods used by various experimenters to determine quantitatively the air pressures on planes and bodies. Experimental data. Illustration by smoke photographs.

Angle of incidence, aspect ratio, plan form. Flight-gliding—horizontal and oblique, flight paths. Loading, speed and power. Range of power. Climbing. Equilibrium and stability—longitudinal, lateral and directional. Automatic stability. Stability devices. The tail or elevator. Dihedral angle. Steering. Propulsion, position of screws and direction of thrust. Stability and speed.

Distribution of pressure on wing elements. Movements of the C.P. on wing sections.

Laws of similitude.

Turning, elevating or depressing, banking, rolling, pitching, skidding, looping, etc.

Oscillations. Gyroscopic action. Effects of fluctuation of stresses on the structural parts. Fatigue of materials and of structural members.

Design.—The mechanical design and construction of aeroplanes. Wing surfaces and camber—forms and arrangement. Monoplanes, biplanes and multiplanes; wing warping; the fuselage, body, stays, struts and attachments; the undercarriage and shock absorbers. Starting and alighting devices. Boxing in and form of envelope. Skin friction. Bearings and joints. Transmission mechanisms. Controls. Instruments.

Materials of construction:—Steel, special alloys, wood, paints, varnishes, etc.

Assembling. Storage accommodation, heating, lighting, signals, etc. Cost.

Dirigibles. Seaplanes and lighter-than-air machines.

Accidents and their cause, analysis.

Applications.—Radii of action. Warfare, sport. Passenger, mail, etc. Speed and distance. Cost per ton mile. Modifications in design.

II.—AERO-ENGINES.

Cycles for internal combustion engines—Otto and two-stroke cycles. Advantages and disadvantages. Ideal and practical thermal efficiencies. Special considerations in designing aero engines of reasonable weight. General theoretical and practical calculations. Weight and power of engines in relation to aeroplane speed range.

Petrol, its combustion and behaviour in the cylinder. Petrol storage in machines.

Arrangement of cylinder and crankshaft torque. Balancing. Vibration, periodic and variable, and dangerous stresses.

Water-cooling systems. Air cooling.

Lubricating systems. Lubricating oils and testing.

Types of aero-engine—horizontal, vertical, diagonal, or V. Radial or rotary and special considerations in design. The aero-engine of the future.

The design of special mechanisms and parts, such as cams, valves, port and pipe ways. Carburettors and carburation.

The fixing of the engine.

Ignition and electrical devices. Sequence or order of firing. Wiring and connections.

Accessibility of parts for rapid de-mantling and re-assembling. Reliability and durability in running.

III.—AERIAL PROPELLERS.

(Their Theory and Design.)

Geometry of the screw and of propeller. Definitions. Air flow and forces on blade elements. Principles and formulæ. Blade shapes and sections. Various graphs for load, stresses, thrust, efficiency, horse-power, etc. Stresses due to centrifugal action and due to bending. The air screw at different speeds of translation. The propeller considered as an helicopter. Lifting effort. Effect of propeller on stability of machine with calculation on couples due to gyroscopic action. Design of propellers.

Materials used in construction. "Laying out" of an air screw. Results of researches on the behaviour of air screws in the laboratory and under practical conditions of flight.

APPENDIX II.

TIME-TABLES.

Part I.*—Aeronautical Engineering.

Hours.	Monday.	Tuesday.	Wednesday.	Thursday.	Friday.
10.0	Mathematics. Mechanics.*	Mathematics Exercises.	Mathematics Exs.	Mathematics.	Engineering Drawing and Design.
11.0	Mechanics. Exercises.	Physics (Optics)	Physics (Heat).	Physics (Electricity and Magnetism).	
12.0	Mechanics.	Engineering Design Lecture (A).	Physics Exercises.	Mathematics and Physics Exercises.	
2.0	Freehand Drawing.	Physics Laboratory.	Chemistry Lecture.	Engineering Workshop.	Physics Laboratory.
3.0	Mechanics Laboratory.		Chemistry Laboratory.		
4.0					Gymnasium.

** Each part covers a session's work.*

Part II.—Aeronautical Engineering.

Hours.	Monday.	Tuesday	Wednesday.	Thursday.	Friday.	Saturday.
10.0	Theory of Machines (A).	Materials (A).	Electrical Technology (A_2).	Engineering Chemistry Lecture.	Engineering Drawing.	Engineering Workshop.
11.0	Mathematics.	Electrical Technology Exercises.	Mathematics.	Engineering Chemistry Laboratory.		
12.0	Heat Engines (A).	Electrical Technology (A_1).	Engineering Design Lecture (B).			
2.0	Electrical Technology Laboratory.	Engineering Exercises.	Engineering Exercises.	Engineering Exercises.	Electrical Technology Laboratory.	
3.0		Power Laboratory.	Mechanics and Materials Laboratory.	Engineering Drawing.		
4.0					Gymnasium.	

PART III.—AERONAUTICAL ENGINEERING.

HOURS.	MONDAY.	TUESDAY.	WEDNESDAY.	THURSDAY.	FRIDAY.	SATURDAY.
10.0	Aeronautical Drawing.	Aeronautical Exercises.	Graphics.	Materials.	Engineering Exercises.	Aeronautical Laboratory.
11.0		Aeronautical Lectures (Principles).		Theory of Machines.	Hydraulics and Pneumatics.	
12.0 to 1.0	Electrical Technology.	Mathematics.		Mathematics.	Engineering Exercises.	
2.0	Electrical Technology Laboratory.	Aeronautical Drawing.	Aeronautical Design.	Aeronautical Lectures (Machines).	Engineering Workshop.	
3.0				Aeronautical Exercises.		
4.0 to 5.0	Gymnastics.			Gymnastics.		

PART IV.—AERONAUTICAL ENGINEERING.

HOURS.	MONDAY.	TUESDAY.	WEDNESDAY.	THURSDAY.	FRIDAY.	SATURDAY.
10.0	Aeronautical Drawing.	Machines and Structures.	Engineering Workshop.	Materials.	Aeronautical Drawing and Design Laboratory.	Aeronautical Laboratory.
11.0		Mathematics.		Mathematics.		
12.0 to 1.0	Aeronautical Lectures (Engines and Propellers).	Engineering Exercises.		Engineering Quantities and Estimating.		
2.0	Aeronautical Exercises	Aeronautical Drawing and Design.	Aeronautical Drawing and Design.	Engineering Exercises.	Materials. Lectures or Laboratory.	
3.0	Engineering Exercises			Aeronautical Lectures (Machines and Design).		
4.0 to 5.0	Gymnastics			Gymnastics.		

*** *The discussion on this paper will be found on page 430.*

ELEVENTH MEETING, 52nd SESSION.

(*See page 369*).

THE ELEVENTH MEETING of the FIFTY-SECOND SESSION was held in the Central Hall, Westminster, on Wednesday, May 30th, at 8.0. The audience, which numbered over 2,500, included representatives of the principal Chambers of Commerce in Great Britain, the Aviation Committee of the Allied Powers, the Stock Exchange, the Baltic, Lloyds, the Diplomatic Representatives of Foreign Powers, the Air Board, the Parliamentary Committee on Aeronautics, the Civil Aerial Transport Committee, and Representatives of the Royal Meteorological Society, the Society of British Aircraft Constructors, the Royal Aero Club, the Institutions of Civil, Mechanical and Electrical Engineers, the Royal Society of Arts, and other learned societies, the London Boroughs, and many others. Upon the platform were Major-General R. M. Ruck, C.M.G., C.B. (Chairman of the Society), the Right Hon. Lord Cowdray (President of the Air Board), Major John Baird, M.P. (Parliamentary Secretary to the Air Board), General Sir David Henderson, Brigadier-General Brancker, Commodore G. N. Paine (Air Lord of the Admiralty), and Mr. G. Holt Thomas.

General RUCK: My Lords, Ladies and Gentlemen,—As Chairman of the Aëronautical Society it is my pleasing duty to thank Lord Cowdray for consenting to preside here to-night and also to welcome him as a member of our Society. I am sure that we all feel greatly honoured that he should preside on this very memorable occasion, memorable not only in the annals of this Society, but also I anticipate in the history of flying.

I have also to express the thanks of the Society to the lecturer, Mr. Holt Thomas, for the immense amount of thought, care, and trouble which he has put into the preparation of this lecture, which may perhaps be considered a fitting prelude to the very important work of the Committee on Aerial Transport, which will commence its sittings shortly under the able guidance of Lord Northcliffe.

I will only make one remark. Rather more than 50 years ago a meeting of a few far-seeing men was held under the presidency of the Duke of Argyll with the object of forming this Society. The members of the Society are described in the daily Press of the time as "not a clique of crack-brained enthusiasts, most of them being shrewd and sensible men of the world, whilst others were distinguished for their scientific achievements"; the chief branch of inquiry was stated to be "the mechanical expedients for facilitating aerial navigation." One of the journals, anticipating ridicule, said: "We know no absolute reason why some of the laughers may not yet survive to take an aerial passage in a new cloud-clipper from London to New York." Well, ladies and gentlemen, it has taken about 50 years to do it, but I think that you will agree before the lecture is over that the shrewd sensible men, assisted by the men of science (a combination which is still the distinguishing feature of the Aëronautical Society), have nearly reached their goal, and that the remnant of the laughers of 1866 will shortly be booking their seats for New York.

I have to add an announcement also of a pleasurable character, for last week I received a cheque for £500 from one of the old members of the Society to be used for general purposes of the Society. In accordance with his request, I may not name the donor, but on a previous occasion, a good few years ago, when aeronautics were at a low ebb, he made a very handsome present to keep the Society afloat, and this action I venture to submit has proved to be of national importance. On the present occasion, on the other hand, the gift has been made, so he tells us, because the affairs of the Society are in such a satisfactory

condition. I am sure the members would wish me to convey to him their very sincere thanks for this most generous gift.

I will now ask Lord Cowdray to take the chair.

Lord COWDRAY: Before taking the chair I must add that I too congratulate the Aëronautical Society on its present success. It has taken 50 years to arrive at this stage in which a hall like this is filled to hear the very latest about aeronautics. Mr. Holt Thomas will tell us how in the future aerial transport is going to add to the amenities of life, and I am sure that after you have heard the lecture and the discussion that will follow, one and all of you will be content with the prospects, with the advantages, with the brilliant future which aviation possesses. Mr. Holt Thomas, as many of you know, is one of the first pioneers in the present great advance. Ten years ago he became an enthusiast in aviation; nine years ago it was his friend, his nominee, who won that magnificent prize of £10,000 which was presented by the "Daily Mail"; two years later he established his firm, and the result was that when war was declared we had a national asset.

General BRANCKER: My Lord, Ladies and Gentlemen,—I agree with almost every word the lecturer has said, until his last sentence, when he implied that the qualifications in aeroplanes and engines which we are demanding for war purposes are not those which will be useful in peace. Personally, I think that we must make commerce and the preparation for war go hand in hand in the future.

I do not think such a principle has ever been thoroughly followed before, but now is our opportunity to strike out a new line.

I do not like war any more than any of you do, but we must be ready for it in the future. I do not think that it will be so difficult to make the commercial machine useful for war as one might think at first. Take the present situation; the machines designed for long bombing raids and carrying heavy armaments are just those which will take us to Cape Town, to Australia, and to other portions of the globe. The aeroplanes which we are using now for the ordinary duties of the army, reconnaissance, artillery observation and photography are just those which will take you to your luncheons in Paris and your week-ends on the Riviera.

The machines which we are using now as fighters are just those which in peace will excel in sporting competitions and in displays of aerial gymnastics, so that I do not think that commerce and preparation for war, so far as aviation is concerned, should be so widely divorced in the future.

We undoubtedly have many troubles in front of us, and we must face much expenditure both in blood and in money.

As Mr. Holt Thomas says, the moment war stops we shall be able to abandon our extreme demands for wonderful performances and devote ourselves to obtaining greater reliability; I think the change will come very quickly, and aviation will become a safe pursuit in a very short space of time. We shall have engines on which you can depend absolutely, and, given those, you will be able to fly in almost any weather without a landing place at every ten miles, with which the lecturer threatened us.

Sir JOHN REES: My Lord, ladies and gentlemen, having heard two speakers, who know all about it, you are to have five minutes from one who knows nothing. I know nothing whatever about aeroplanes or the art of flying. I have been asked to say a word or two solely with regard to the commercial side of aviation. As one who has passed many years of his life in India, I can appreciate more than those who sit at home what it is to go to Baghdad in two days after having taken two months to get there. The particular object of the lecturer was to dwell upon the commercial view of aeronautics. Well, I sincerely hope that when that question comes, as it must almost immediately come, that it will not be met in the spirit of obstruction in which that of the Trade Corporation was met in the House

of Commons. Only the other day we were reading the romances of Jules Verne and Wells, and regarded their visions as only too fantastic, but now really I feel surprised and regret that I am not going home by one of the services. Mr. Lloyd George has told us that we are always too late; well, let us not be too late on this occasion. There is great reason to believe that we were rather late with our Air Services at the beginning of the war, and I hope that we shall not be late in the commercial war, and that at any rate we shall excel the Germans.

As regards India, I see in the audience Lord Montagu of Beaulieu, who has been there since I have, and who has an extremely practical knowledge of this subject. He, I believe, is going to address you, and you will be grateful if I do not extend my five minutes. But I am convinced of the need of aviation not only in India, where we were eight weeks in riding slowly over the ground, but in work in the City of London. How a little business in Brazil might have been easily put right if only one of those rapid journeys could have been made which are going to be so easy in the immediate future. In all seriousness I regard this lecture as one of most extreme importance—a vista of a future well within reach. I congratulate the Society on having as chairman Lord Cowdray, who is also not only here in his official capacity, but one of the greatest captains of business and one to whom we all naturally look.

Lord MONTAGU OF BEAULIEU: My Lord, ladies and gentlemen, I would like also to say that as regards landing stations that in India we have already started them. I would like to say how I agree with General Brancker that war development will help commercial aeronautics after the war. If we had had no war we could not have got half so far as we have. I consider the war has helped on aviation by 30 years. We owe a very great debt to the Flying Services. I think Mr. Holt Thomas has been very moderate in his estimate of the future, and has combined knowledge with imagination.

Colonel O'GORMAN: My Lord, ladies and gentlemen, in five minutes I shall have difficulty in criticising what Mr. Holt Thomas barely sketched in one hour, and therefore shall attempt only to congratulate him upon the excellent start he has made. It was my privilege as Chairman of the Lecture Committee to invite Mr. Holt Thomas to speak and to let us have the benefit of his thinking in this matter. I think we had an especial advantage, because he is a keen business man and an enthusiast, and he has started on the right ground. In 1909 I had the pleasure to go there with Mr. Holt Thomas. We agreed between the interesting sights to keep a most careful record of our expenses, and at the end of our visit there Mr. Holt Thomas suggested that we should toss for who should foot the bill, and I think his foresight was strictly justified on that occasion!

There is one thing which Mr. Holt Thomas has touched upon with which I am completely in accord. The essential basis of speed, that is the fundamental basis, but there is another speed, and that is the speed with which it is possible to instal commercial aeronautics after the cessation of hostilities. One of the most difficult things to undertake is the building up of a structural organisation, and in quite a short time it is possible to lose much. After a small pause the interest built up crumbles into a small mound of sound; all is lost unless it can be kept going by a rapid following on from one thing to another—for example, the military to the commercial. I think it would cost five million sterling if there were a substantial pause between the time when the commercial part steps in. In that way also speed is fundamental to the success of our British aeronautical position. I do not think that in five minutes it is possible to begin to touch on the many interesting points.

As regards the cost of maintaining flying grounds, I can assure him that the large majority of his grounds in the line would cost very much less than that per annum; that has been the experience of the Italians. It must be remembered that they are only alighting grounds, not aerodromes. I am glad to say that

everybody has not been asleep, for four years ago I was asked by a firm of railway constructors to organise a weekly service down a river. It was quite easy to see that the service would be very prompt and very economical. I would like to suggest that Mr. Holt Thomas has given us two papers, one of which I hold in my hand and the other which he read. Listeners will find it a good thing to read the paper.

Mr. WHITE SMITH: We are greatly indebted to Mr. Holt Thomas for his most interesting lecture and for the splendid films which he has shown us to-night. They give an excellent idea of what we may look for in the future, but at the same time I think we must not altogether be led away by them; especially is this the case with regard to the figures which Mr. Holt Thomas has put before us when we come to look into them. There are a number of points on which criticism may be offered, for instance the figure of £2,500 as the price of the machines which would be engaged in the Aerial Transport Service is to my mind utterly inadequate, especially when it is borne in mind that the figures of profit given by Mr. Holt Thomas are based on machines which are capable of carrying twelve passengers at a time. The time will come when passengers will not be content to carry a very small amount of luggage, which Mr. Holt Thomas's passengers shown on the film to-night were carrying. It is not, however, altogether fair to criticise the figures at this early date, but my point is, that in order to bring about this great development of civil aviation a great expenditure of money will be called for, and it is, therefore, necessary that the Government and the public behind them should support the development of the aviation industry for commercial purposes. We have had the great help of the military and naval services during the war, and we want that to continue after the war, while at the same time the development of the new types of commercial machines is taking place. The constructors must be properly supported by the Government after the war, and I cannot help thinking that it is in the interests of the Empire that this development should be brought about as it undoubtedly will link up the distant parts of the Empire more closely with the Mother Country.

Mr. HANDLEY PAGE: I am sure that every one of us here this afternoon must have felt like an attendant at the Spanish Court when Columbus described his theory of the new Continent; I am sure that I feel like that attendant. It has been my privilege to be associated with one of the machines shown in the films, which has carried a load of six tons, and as it has done this it is possible to fly long distances or to carry very considerable weights. I always think a small fighting aeroplane is rather like a motor-bicycle, and until one has passed that stage and come to the luxury of the Rolls-Royce, only then will you get people to make the journey. You have seen from the films the inside of an aeroplane cabin, and the comfort that can be attained.

There is a matter which must not be neglected, and that is the question of winds. If one comes to work out the average of winds, the time is very little increased by adverse weather conditions.

Lord COWDRAY: Ladies and gentlemen, I am sure there is no one here who has not enjoyed to the full the lecture. You will have noticed that all the speakers particularly took care with the lecturer to point out the difficulties ahead. Before aviation is a commercial proposition there are many things to be solved. You may have noticed on the film how a mailbag dropped into the net. One of the speakers spoke about the hiatus that may occur to the great detriment of the industry between the declaration of peace and commercial means of aircraft. There unfortunately is a change which has to be faced. It would be impossible in my opinion, whatever plans we made between now and the end of the war, to expect to continue the aircraft industry at the high pressure that it is now, and I therefore agree with the lecturer in thinking that the industry ought to be specially treated by the tax-gatherer with regard to the excess profits. We have to bear in mind that after the war there will be thousands of aircraft, thousands of skilled pilots,

many thousands of mechanics who are a great asset to the nations. They have been splendidly trained, they have proved their worth by going through the difficulties and the dangers of their occupation successfully. It is essential that these men should be used if it is possible to use them in commercial aviation at the end of the war. I believe that it will be found that Mr. Holt Thomas's estimate of costs is somewhere near the mark; it is difficult to say what they will be; they will not exceed 5s. per mile. The Government ought to help. It cannot be expected that commercial aviation can step into a business that will produce 5s. per mile right away. That money is required to cover the costs; it is only reasonable that something should be added for a fair profit. It will be years, however rapid may be the growth, before the trade itself supports a service which its needs demands. Where in the past the mercantile marine has connected nations, aviation will in the future combine them together. As General Brancker remarked, you will go to the Riviera for the week-end, as one went to Brighton before the war. I cannot express too strongly my opinion speaking generally of the future as laid down by Mr. Holt Thomas of commercial aviation. It is bound to come, it will come quickly, it will come successfully, and I expect Government assistance for possibly the first five or six or seven years. Imagine what that means. Think of a future when you can go at 100 or 120 miles an hour instead of in a cross-country train 20 or 30 miles an hour; it will shorten time in many ways. It will lengthen life in so far as it will enable us to do so much more than we have been able to do in the past. One can hardly picture the advantages aviation will have. Our congratulations and thanks are due to him for the care he has bestowed on his lecture. Without his experience the lecture would not have had the value that it has. Without his knowledge of aviation he could not speak with the authority he has. You know he is spoken of as the Napoleon of aircraft manufacturers. That describes his position very faithfully, and to Napoleon I think I may, on your behalf, render our thanks.

Communicated by Mr. J. R. Pannell.

The paper lays down in a very clear and concise manner the possibilities of the commercial use of present-day aeroplanes.

It appears to the present writer, however, to be very optimistic in the matter of the speed which is likely to be attained. While it is true that some modern high-speed scouts fly at speeds of 125 m.p.h., the speed of the large machines illustrated would hardly exceed 90 m.p.h. Moreover, the landing speed of the 125-m.p.h. machine will probably exceed 50 m.p.h., a value which is, say, 10 m.p.h. too great for a passenger machine. Unless the aerodynamic performance of the machine can be improved in certain respects, the landing speed of the 125-m.p.h. machine can only be reduced if the machine is flown at a much less efficient altitude, a condition which is presumably undesirable in commercial aeronautics. Extensive experiments have been carried out on model aerofoils in the wind channels at the N.P.L. in order to find a wing which would have a higher efficiency, a low value of the lift, while retaining the same value of maximum lift, these being two characteristics which would enable a lower landing speed to be obtained. The results, however, suggest that any large improvement upon the wing sections at present in use is not probable.

The author's allowance of 45 m.p.h. for wind and stops is perhaps on the high side, but if the flying speed is to be, say, 90 m.p.h., the overall speed of 45 m.p.h. begins to approach that of express trains, and the desirability of the use of aeroplanes for mail and passenger traffic in England appears doubtful.

The suggestion that mails could be dropped into nets for towns *en route* is ingenious, but in view of the known difficulty of bomb-dropping, the pilot is to be congratulated on the accuracy with which he dropped the bag into the small

net shown on the screen. It seems probable that the bag would as often fall outside the net as into it.

For oversea or long-distance transport the case is much stronger, but landing places in mid-ocean appear to present some difficulty. If the landing ship is moored, a very large deck will be required. If, on the other hand, it is proposed to reduce the relative velocity by steaming the ship up wind, dangerous eddies and up or down currents will be encountered by the aeroplane just before landing. The landing difficulty will, of course, be much increased in rough weather.

With reference to the "Porte" Flying Boat which was shown in flight on the screen, can the author give any particulars as to the force which it is necessary for the pilot to exert in moving the controls during flight? Both rudder and elevators appear to be unbalanced, and the size of the machine suggests that the force required must be such as to cause considerable fatigue to the pilot.

[Mr. Holt Thomas remarks as to the discussion:—"The hour was getting on and I had not time to answer those who spoke after me; but with reference to Mr. J. R. Pannell's remarks, I should like to say that the machine shown on the film was not of course the commercial machine of the future, which was an imaginary machine, perfectly easy to design to-day; and the weights I gave could be easily transported at 120 miles an hour, the speed I took as the average being only 80 miles per hour, *i.e.*, allowing 40 miles an hour for wind and stoppages. With reference to General Brancker's remarks, there was a slight misunderstanding, I think, on what I said. Whilst quite appreciating the fact that the war had enormously advanced aviation, I said that we were devoting our attention to climb, visibility, gun positions, etc., all of which points would not enter into the commercial machine; and that when we came to deal with the commercial machine, we should be devoting our attention to other points which might not be useful for war."—EDITOR.]

TWELFTH MEETING, 52nd SESSION.

(*See page 390*).

An ordinary general meeting of the Society was held on Wednesday, June 6th, at 8.0 p.m., in the Theatre of the Royal Society of Arts, Adelphi, London. Major-General Sir DAVID HENDERSON, K.C.B., D.S.O., Director-General of Military Aeronautics, presided.

There was a very large attendance. Capt. B. C. HUCKS, R.F.C., gave a lecture, entitled, "A Further Three Years' Flying Experience."

A discussion followed.

Wing Commander A. H. LONGMORE, R.N., said he agreed with the lecturer in regard to the question of flying with instruments. They had found in their long patrols that flying over the sea was much the same as flying in a cloud. The horizon, sky, and sea all merged into one. At 6,000 or 7,000ft. one might just as well be up in a cloud. Young pilots when they first went out of sight of land had great difficulty in keeping a straight course and the right way up and preventing side-slips. They had to rely entirely upon instruments. He agreed that in the early stages they ought to be taught without instruments, but subsequently, for sea patrol work, they ought to be taught to fly with their heads inside a box, by the instruments, and the instruments must be good enough to enable them to do it.

He had seen "Penguins" on the ground in France. He thought Captain Hucks would realise that there was great danger of collisions all over the aerodrome when, say, 150 pilots were being trained on a half square mile. Possibly only about five at a time could be employed.

He was rather surprised that a bit of string had not been used more as a side-slip indicator. Commander Briggs, who returned from imprisonment in Germany after being out there two and a half years, got a piece of string and put it on one of their new machines before making a flight in it, and he flew very nicely.

The medical test might in certain cases lead to erroneous impressions being formed of a weak pupil. Highly-strung pupils if sealed up in a box and sent up to 20,000ft. would probably get a little nervous. It was the same with other shock tests. They would be expecting the shock, and this would affect their hearts, but they might turn out very excellent pilots. A bullock-natured young fellow "with hands like an ox," and who would never make a pilot, might stay in a box and go up to 20,000ft. comfortably. The question of obtaining warmth from the engine would have to be gone into when dealing with single-seated pilot machines. Some provision for warmth should be made.

Lieutenant-Colonel W. D. BEATTY, R.E., R.F.C., said that he disagreed with the lecturer on the subject of the reliability of engines. He thought that in fact modern engines are too reliable for training machines, and that it would conduce to the better education of pupils if it were arranged that their petrol taps should jar shut at irregular intervals so as to give them practice while learning in the art of knowing what to do in the case of emergency.

He disagreed with the lecturer on the subject of spinning. A spinning descent is an excellent way of getting down vertically without permitting the machine to acquire a dangerously high diving speed. He did not agree that engines should be designed not to spin. It was exceedingly useful in war.

Mr. HARRY KNOX said he was in aviation works at Brooklands for four years prior to the war. During his early experience, when he first met Captain Hucks,

it was thought that the greatest motor car racers would be the best pilots, but that had turned out to be a great fallacy. Mr. Sopwith was a fine motor driver, and he turned out a magnificent pilot, but the finest type of pilot he (Mr. Knox) had known was a sound yachtsman. He knew the wind, and controlled an instrument which, to some extent, was uncontrollable. A motor car had powerful brakes and terrific acceleration, but with a yacht you had to lose your way and there was no brake to put on, and it was the same with aeroplanes.

Colonel Beatty referred to spinning. When he (Mr. Knox) was at Brooklands a pilot got into trouble in clouds 6,000 or 7,000ft. up. He said he had no idea except that the speed indicator was "completely off the map." He deliberately got himself into a spin. So long as he was doing a vertical dive and spinning he could not reach too high a speed. He stretched the machine to a considerable extent.

With regard to the medical test, this had been considerably discounted at the French Ecole Acrobatique. In some cases men of cast iron nerves, quick judgment and quick decision had made fine pilots, but in other cases they had had pilots whom they had only just allowed to pass the medical test. He thought they actually took the register of blood pressure from sudden shock on the arteries. Some of those men had turned out the finest pilots in France.

Captain WILLIAMSON, R.F.C., said in flying in a cloud he had found an air-damped compass of very considerable use. He had at one time to fly through thick clouds almost every day. The second or third time he found himself in a spin. He took up a large compass—the largest he could obtain—which, of course, was damped by air. He had this suspended above the ordinary compass used by pilots, and found by its indication that the machine was turning considerably earlier than any move of the main compass. From the time he commenced to use the air compass he had no trouble in clouds.

Mr. H. P. PANNELL (National Physical Laboratory): He took it the preliminary to a loop was always at high speed, presumably the machine dived, and the pilot would pull his elevator and commence the loop. In view of the stress set up in the aeroplane during the loop, he was interested to know how the pilot judged what pull a pilot actually puts on the lever of an aeroplane in looping, and also what happens if the engine stops low down in a loop, and what is the difference between a spiral dive and a spin. He suggested that a record should be kept of the most minute details of all accidents which occur, at any rate at home, and said that if these details were tabulated they would be of great value to designers. He remarked that he had recently seen an aeroplane near Twickenham rotating round its longitudinal axis, and he would like to know how it was done. He desired to say how much as a technical man he appreciated Captain Hucks' lecture, and said that technical men in the industry would like to know very much more from practical men like Captain Hucks.

Mr. TAYLOR, of Waring and Gillows, inquired what Captain Hucks considered to be the average life of a regular pilot. He recalled that at the last lecture Mr. Holt Thomas had spoken of long journeys by air without mentioning how long he considered pilots would last at such work. Mr. Taylor also asked Captain Hucks for his opinion concerning the relative fatigue of flying pre-war aeroplanes and present machines.

Captain HUCKS, in replying, dealt first with Commander Longmore, and suggested that it would be very much better to have collision between penguins on the ground than between pupils in the air; and he remarked on the curious magnetic attraction which one machine in the air has for the pilot of any other until he becomes an experienced flier. Anybody who has learnt to ride a bicycle will recall that lamp-posts have a very similar magnetic influence.

As regards spinning, he very much doubted whether an aeroplane in a voluntary spin performed the same evolutions as it does in an involuntary spin. He

suggested that a voluntary spin was rather a species of a spiral dive. He agreed that the qualifications of a yachtsman are valuable, but the man who drives his car with proper feeling for his engine is more likely to make a satisfactory pilot, and the mechanical knowledge of the motorist was of great value to the aviator. He did not claim that the crack racing driver made a crack pilot, but he did claim that all experienced motorists have made good, useful average pilots. The man he wanted to eliminate was the chronic machine-smasher.

As regards French medical tests he did not advocate that they should be used to throw out those who do not pass them satisfactorily, but that they should be counted against the man so that after a period of probation if he were not satisfactory that would be the deciding factor, helping to explain why he would never be likely to make a good pilot.

As regards air-damped compasses, any compass would be discounted in its accuracy by the effect of bad bumps in the air.

Describing the active life of a pilot, he said that it depends on the nature of his flying. Any man who puts in six months of flying on active service will probably need a very long rest, but that a pilot flying at home on modern machines, and using reasonable precautions, ought to be able to fly for ten or fifteen years.

On the subject of looping, he said that a certain diving speed is required to get over the loop, and this depends on the reserve power of the machine. A military machine will loop its normal flying speed, whereas the old 50 Blériot needs a dive of a couple of hundred feet to get up the necessary speed.

It is common knowledge that Service machines have been broken by being looped too suddenly, and he believed that it is possible to break any machine in the air by treating it too roughly. It is the same thing with cars, because if one takes a fast car too sharply round a corner, one either breaks the wheels or bursts the tyres, or turns the car over.

It might be quite possible to make a machine unbreakable by increasing the factor of safety, but, then, it would be too heavy for active service.

With regard to the engine stopping on a loop, it depended what part of the loop. He had tried experiments in getting a machine to loop without the engine. To do this more than the normal speed had to be got up. The trouble came when the vertical upward direction was reached. The speed died away quickly and the machine either side-slipped or fell back on a tail-slide. He had had a tail-slide to such an extent that the propeller started turning in the other direction. If a certain amount of judgment and touch were used in pulling the machine out of its speed and the pilot could see what he was doing the risk was not very great. With regard to the elevator being used as a rudder when the machine was in a spin, the main planes were generally over 45 degrees from the horizonal line, and when the pilot attempted to pull the machine out he held it in the spin because he directed it round and round in a circle.

He had not done a lot of rotating machines on their longitudinal axis. He had had a machine over on its back on one or two occasions, but had not done a continual turn-over. He thought it was only a question of warping the machine over. When it was warped over beyond 45 degrees the rudder had to be brought into play to begin with, and on a steep turn the pilot instinctively moved the rudder. So far as the turning over was concerned there was no mechanical reason why it should not be perfectly safe.

The difficulties of flying in a cloud were due to the one point that there was no fixed object to indicate when the machine was turning. If a glimpse of the sun or of any fixed point could be obtained one could tell whether the machine was turning or diving, and what position it was assuming in relation to the earth. Some instrument was wanted which would give a constant point which did not move with the machine. He

had not yet flown a machine beyond 15,000ft. high that had not dropped a tremendous amount of power. The best result he had had was with a machine which he flew to a height of 15,000ft. and which only dropped ten revolutions. The air being thinner, it required less power to give the same number of revolutions. A drop shown in the revolution counter also showed that the power had dropped considerably. If the power of the engine was maintained all the way up the revolutions would increase because the resistance of the propeller was lost. A peculiar sensation was experienced in piloting a machine on a climb when one got somewhere near what was called the "ceiling." At about 21,000ft. a point was reached where there was only one flying speed. The speed shown on the indicator was fifty miles an hour. If you put it at forty-eight it tended to sideslip and at fifty-two miles it lost height.

Lieutenant-General Sir DAVID HENDERSON, D.S.O., K.C.B., in moving a vote of thanks to Captain Hucks, said he had touched on many subjects and had given enlightenment on a great number of them. Every nation that had had to try to keep up to aeronautic supply had found that the design advanced so quickly that before manufacturers could get into full play the design was obsolete. There was always the choice between having a few of the very best machines and a large number of the next best. It was a difficulty to which there was no solution, and they had not been able to get over it. As to accidents, as far as the records showed, they resulted from a combination of engine failure and faulty piloting—though he by no means intended to blame the pilot, who was taken unprepared by engine trouble and did the wrong thing. Accidents due to faulty aeroplanes were very rare. Still there was no machine, except that used in training, that the pilot could not break, and he did not require to be a Hercules. The danger to fast machines when they travelled nose down had been a subject of investigation, and it was found that they reached a terminal velocity when the air resistance equalled the force of gravity, with the addition of the force of the engine. The breaking occurred only when the pilot tried to pull up the machine, and this was an operation requiring very delicate handling. It ought not to break if there were no faults of material or construction. In regard to the question of medical tests, the French had gone for nervousness, and he thought they were on the wrong tack. It was found that physical disabilities were of more effect than nerves. If they wanted men who could resist sudden shocks they might get one constituted like an ox, but this was the very last type that would produce a good pilot. He believed that we had fewer failures among pilots than the French. A large number of youths had been found unfit for flying at the front, and some people had said that they had "cold feet," but in reality they had recognisable physical disabilities, and after a fortnight in hospital had been turned out fit, and several were flying now. The primary failure had resulted from flying at high altitudes when they had something the matter with them. In nine cases out of ten it had nothing to do with nerves. He was well satisfied with the class of pilots who had been chosen under their system. The question had been raised whether a good horseman or a good motorist made the best pilot, and he preferred the horseman, for the horse was a conveyance that had an intelligence of its own and needed much closer watching than an engine. Also he had noticed that good horsemen often made good motorists, but good motorists did not generally make good horsemen. It had been observed that some airmen used horsey terms in speaking of their machines, and one had said, "She is all right if you treat her well, but if you don't she turns round and savages you."

General RUCK moved a vote of thanks to General Henderson for presiding. This was unanimously carried and the meeting ended.

THIRTEENTH MEETING, 52nd SESSION.

(*See page 403*).

An ordinary general meeting of the Society was held on Wednesday, the 27th of June, at 8.0 p.m., in the Theatre of the Royal Society of Arts. In the absence of Sir Edward Busk, M.A., LL.B., Mr. A. E. BERRIMAN took the chair.

Mr. A. E. BERRIMAN: Ladies and Gentlemen,—The chair this evening was to have been occupied by Sir Edward Busk, a firm friend of this Society and a prominent figure in the educational world. I feel sure that you will keenly regret his absence, the more so as there was no time in which to obtain an adequate substitute. In the present emergency, our Chairman of Council, General Ruck, has displayed his characteristic resource and kindly tact in asking a student to preside at the discourse of a master.

With others, I share an abiding interest in the subject about which the authors are to speak to-night, and I shall agree with them whole-heartedly when they tell you, as they will tell you, that education is itself a subject requiring as careful and laborious study as any of those on which we have had such an admirable course of papers in the present session.

For the human race, education is a biological necessity. We are not born as some species are, in a highly developed state. On the contrary, although we come into the world with inborn capacities of varying degrees of strength, it is hardly too much to say that the characteristics of the educated man are one and all acquired. It often seems to me that the significance of this fact is not appreciated as it should be. One of its consequences is to force home to the mind the realisation that education is a lifelong process, and it is, I think, from this point of view that we get a proper perspective of the importance of laying the educational foundations truly and well.

But since everybody has not the same means at his disposal, it is absolutely impossible to lay down one form of education for all, and although I personally believe and have often said that a nation like ours, which cannot afford to let its masses remain illiterate, would find it a first class investment to pay for the education of its best brains, we are as yet far from a common acceptance of any such view, and we must adjust our ideas more closely in keeping with facts as they exist. It is the fact of the diversity of individual means that must always be borne in mind in the study of educational problems, and I venture to emphasise this point because while we may have differences of opinion this evening as to whether the authors' system is the best of all possible methods, we should at least be in accord in appreciating it as actually fulfilling the requirements of an important section of the community. The progressiveness of the Northampton Polytechnic in so early providing facilities for the study of aeronautical science is both well known and appreciated by the members of this Society, and it is with a corresponding measure of attention that we shall listen to the advice of one whose foresight and influence has been responsible for such good work.

There is yet a further point in connection with individualism in education which is of equal importance. Certain countries have tried to stamp their educational products into a uniform pattern of grades. In England we are less fond of system for the sake of system, and there has grown up an individuality of character about our educational establishments which has, in my opinion, been a tower of strength to the State.

It is not unnatural that this variety should be the cause of some confusion,

but it is a defect that can, I think, be overcome very readily by close co-operation between the educationalist and the engineer. To me it seems the most important of all educational matters to be accomplished at the present juncture, because I believe that this co-operation will be one of the corner stones upon which the future industrial supremacy of Great Britain will find its true support. The present meeting of the Aëronautical Society to hear a paper on education is a practical illustration of the working of this principle, and adds warmth to the welcome that we accord to Dr. Walmsley and Mr. Larard this evening. Incidentally, it makes me realise that I shall myself be discordant with the ideal of co-operation if I delay any longer the execution of my principal duty, which is to call upon Dr. Walmsley to read their paper, entitled, "The Training of Aeronautical Engineers."

Dr. R. MULLINEUX WALMSLEY, D.Sc., F.R.S.E., read a lecture by himself and Mr. C. E. Larard, M.Inst.C.E., on "The Training of Aeronautical Engineers."

A discussion followed.

Mr. HENRY FOWLER: I have had the advantage of teaching in evening classes in times past and I appreciate the educational value of the paper to the teacher as well as to the student. I cannot but read with very great concern the state of the education in this country at the present day owing to the lack of students, as the young men who would, under normal conditions, be receiving technical education are now carrying out their duty elsewhere. This will prove a very serious menace to the engineering work throughout the world in the near future. At present it is a matter of the greatest difficulty if we lose a man to get him replaced.

I would like to thank Dr. Walmsley for the broad view he has taken in the remarks he has interpolated during the reading of the paper. So often one finds that with a teacher the man is lost sight of in the student, although after all it is the qualities of the individual as a man that are of the greatest importance. The authors have stated that many people are speaking of education at the present time, but few are bringing forward any new ideas. One feels that the whole question is like that of comparing timber and steel. With timber, each particular part has to be considered individually, whereas with steel one looks for uniformity through the mass. So each student must be considered individually.

With regard to training, I feel that the proper method is that if a young man has the advantage of the necessary time and money he should first go to the shops, as is the arrangement we have at Derby, where he is allowed to attend a Technical College two mornings a week. He should then go to a University and take a degree, returning as a pupil to complete his practical education. We find that the University training does not, as a rule, cover metallurgy, and therefore Dr. Arnold, at Sheffield, has arranged a special course for this class of pupil.

I appreciate very much what the Aëronautical Society has done with regard to their scheme for lectures, and hope that we shall have a series of these at Farnborough.

Not only the question of the students but also of the teachers should be considered, as, probably owing to the question of remuneration, one finds that one does not always get the right man in the right place. It should, I feel, be recognised that a man who has the teaching of the manhood of this country is doing one of the noblest and best works.

Mr. LEONARD BAIRSTOW, F.R.S.: It is a pleasure to find the authors giving a valuable lead on the subject of future aeronautical education. The paper looks some years ahead and deals most fully with the earlier stages of the training of aeronautical engineers. In the following remarks it is proposed to refer only to the highest education, such as can be given to students who have made arithmetic,

geometry and calculus so much their own that they can concentrate on the object of their inquiry without expending conscious effort on the processes involved.

For such students, not only in aeronautics but in all branches of mechanical engineering, the coming of the aeroplane is a great event. Quantities previously denoted by symbols, u, v, w, p, q and r, have now received names by means of which they are readily visualised. The first three become an aeroplane, the speed of flight, the rate of side-slipping and the rate of climbing. The three latter letters are interpreted as rolling, pitching and turning. The extension from the two dimensional motion of a slip to the three dimensional motion of an aeroplane has produced the first well-known example of a widely used language for motion of the most complex character. As a consequence, aeronautics will probably furnish many of the University examination examples of the future in the subject of rigid dynamics.

The study of forces and couples, as it occurs in wind-channel experiments, rapidly removes from the equations of motion and the formulæ of solid geometry most of the difficulties presented to a student in his early attempts to resolve forces and couples in three dimensions.

In another direction aeronautics makes a strong appeal for high scientific training in those capable of it. The mathematical investigation of the motion of a viscous fluid has so far defied all efforts at solution except in a few cases of little importance to aviation. The problems call for new methods and for such methods as are usually associated with the engineer as distinguished from the mathematician. Speaking very generally, the engineer attacks a problem because he wants the answer, whilst the mathematician seeks a problem which has a pretty solution or in some cases finds the solution and searches for a problem to fit it. The limitations of the latter methods are too great for aviation to be content with it and the problem of solving the equations of motion probably lies in the development of approximate methods of solution of complex equations of motion. This view is a natural corollary to that of the authors of the paper, as they ask that mathematics be looked upon as one of the tools of the engineer and not as an end in itself. The period of probation used in the earlier stages of training in the courses outlined by the authors will probably need to be supplemented by others before the final selection of students for the highest available training can be satisfactorily undertaken.

Lieutenant A. R. Low said that with regard to the differential equations referred to by Mr. Bairstow, the present position was that the mathematicians had become pure mathematicians and the physicists had become experimental physicists. The mathematical physicist was scarcely known at the present day. He did not know more than half a dozen in the United Kingdom who explained physical problems by abstract processes of reasoning, which were called processes of mathematics as applied to physical problems.

In regard to the solution of the equations of viscous flow, Major Filon, at the Air Board, predicted physical results by abstract computations, and Professor Bryan predicted certain facts regarding stability by abstract reasoning before practical aeronautics had discovered them. Professor Bryan predicted the spiral nose dive before pilots had discovered that certain accidents were fatal. To the half dozen mathematical physicists he must add Mr. Bairstow.

He (Lieutenant Low) had lectured and advised apprentices for years what to do with regard to evening classes. Their lecturers soon separated those who must stick to the drawing-board or the shops from those who were capable of studying workshop problems in abstract terms and restating the result back into an engineering advance. The aviation industry was in a state of rapid growth. They were taking men raw, from their point of view, and forcing them through special training and using them as soon as they were in the least competent to increase the output of aeroplanes, and their lecturers added to that the process of rapidly

educating a very large number of newcomers for the vital war process of producing enough aeroplanes to win the war in the air.

Colonel DE VILLAMIL, R.E.: I should like to make a few remarks about the teaching of mechanics. My sympathies being with the young student, I think the subject is made as difficult and as unpleasant to him as I can imagine.

If the object of education is to pass examinations, the present system is perhaps very fairly successful. The "raw material" is put into one end of the machine, a professor turns the handle, and the bachelors of science pop out of the other end, just like buttons.

If, however, the object is to learn mechanics, a good deal more clear thinking is very desirable; much of the terminology of the text books lends itself to very sloppy reasoning.

To give some examples, comparatively few students *really know* the meaning of the word "velocity." This is not wonderful, for if we open Dr. Cox's "Mechanics" (I select this book as its date is 1909, and as it is published by the Cambridge University Press), we find, at page 110, "The *velocity* of a point is the rate at which it is changing its place."

This may be good enough for an examination paper, but it gives a very poor idea of what "velocity" really *means*. A little later Dr. Cox mixes up "velocity" and "speed," as if they were synonymous terms. He speaks of "a *velocity* of one foot per second," when, obviously, the proper word is "speed." It is not uncommon to read of "uniform *velocity* in a circle"—which verges on barbarism.

In Mack's "Mechanics" we find, "The *distance c* (*sic*) traversed in a second of time *we call the velocity*." [Italics added.]

What are we to think of a paragraph like this? (from Dr. Cox's "Mechanics"). "If the velocities OA, OB, are *communicated* to a point during one second, it has *accelerations* (*sic*) OA, OB."

The student would, very naturally, suppose that *a velocity is an acceleration*. Therefore he will have been led to believe that velocity = speed = distance = acceleration.

Dynamical similarity is not even referred to by Dr. Cox. Very much mystery is made of this, which is rather reserved, as a "special preserve" for a few professors. The subject is not difficult, and I think every book on dynamics should commence by giving an outline of it. I am afraid, however, that the effect would be rather like that of eating of the Tree of Knowledge; "the day ye eat thereof, then your eyes shall be opened, and ye shall be as the gods, knowing good from evil."

"Fluid friction" is an expression freely employed in aerodynamics. No one knows what they mean by it when they employ it. The explanations offered only add to the confusion, until, at last, the student gets a kind of confused idea that the particles of the fluid are *rubbing against one another*, just as you rub a match against a match box.

The clumsy way in which the "composition of forces" is taught is lamentable. Firstly, the word "Force" is used, almost indiscriminately, in *four different senses*. I know of one text book where it is used in *three different senses on the same page*! It is most commonly used as if it were a kind of arrow, which you can use for poking things about with; or a kind of locomotive you can hook on to, or unhook from, a train. This is pure metaphysics and not mechanics at all. It is a relic of Fetichism.

"Force" is *a rate*—a rate of change of momentum—and no more resembles an arrow or a locomotive than a bank rate resembles a sum of money. What

would be thought of a banker who said, " the bank rate was £100," and that he was going to *apply it* to buying War Loan?

Pages in the text books are devoted to the " parallelogram of forces "—(why always " forces "?; why not, occasionally, " velocities " or " displacements "?)—the " polygon of forces "—some of which require much imagination to see the resemblance to a polygon—and to " graphic statics."

If the young student were thoroughly taught that *all* quantities are either *vectors* or *scalars*, he could learn all this in a very few minutes. He would, further, never afterwards muddle up *displacement* and *length*, *surface* and *area*, *velocity* and *speed*, *force* and *pressure*, *velocity* and *acceleration*, *velocity* and *space*, etc., etc., in the way so frequently done in " Elementary Text Books."

British students are not deficient in brains; but they want to learn how to *use* them properly. The essential thing is to *teach them to think clearly*.

Lieutenant A. P. THURSTON, D.Sc., said the Northampton Polytechnic syllabus practically coincided with that used at the East London College for the last eight or nine years. The only difference was that perhaps more stress was laid on metallurgy and the properties of timber and materials.

He was not sure that he agreed with the authors when they said " the effects of fatigue on the various parts of an aeroplane structure due to repetitions and variations of stresses does not appear to have attracted serious attention in connection with aeroplane work." That subject had received the fullest attention from many engineers since the declaration of war. It was also stated that the materials of construction had not been properly standardised, but much attention had been given since the beginning of the war to the question of standardising every part.

The paper stated that the strength of different kinds of timber bears a linear relation to the density. That had been well known for many years. It not only related to the compressive strength but also to the transverse and tensile strength. It did not, however, relate to the sheer strength. That was a peculiar thing, and a lot of research had been done in that subject. Oak did not agree with that law, as it fell very much below the straight line, and was unsuitable for the construction of aircraft.

It was important to have a big reservoir of trained scientists and engineers. It was his duty at the beginning of the war to recruit large numbers of men for the Engineers. Afterwards it was necessary to recruit large numbers of men for aeronautics. The only thing that could be done was to take men who had been trained in science and general engineering and let them shake themselves down into the work of the construction and development of the aeroplane. The future of aeronautics was immense and the aeroplane would increase the possibilities of traffic with other parts of the world in future, and each development of science called for a higher training in the engineer.

Captain KENNEDY said: I think the authors have done the Society a very great service in bringing this important matter before it in so clear and concise a fashion, and I think it follows that it is up to the Society to see that there shall be some practical result.

In common with some few others present, I possess the doubtful advantage of being able to go back in memory to the eighties and nineties of last century and I can remember when the electrical industry was at a similar stage to that of the present-day aeronautical industry.

We know how slowly development took place, and that educational work of the type indicated in this paper had to wait until small firms grew into large combines, and the heads of these great firms realised that technical education for their staff was a matter of the first importance.

But while there is some parallel between electrics and aeronautics, there are also violent contrasts. Electrical development took place in times of peace, and

we could afford to muddle along and wait, but aeronautical development is taking place with great rapidity, and while this country is fighting for its life.

Mr. Fowler has pointed to a serious danger in that technical education in this country has almost ceased to exist. If the present conditions continue, in two or three years we shall look in vain for men to direct our technical industries.

Let us carry our minds back again to the electrical industry in its early stages. If it had had its activities centred in an Electrical Board, would the members of that board have thought it their duty to take practical steps to provide an educated personnel?

I suggest that the proper sequel to the excellent work which the authors of this paper have done is for the Society to find out with whom rests the responsibility to take up this important question. The Aëronautical Society should make some definite suggestion, either to the Air Board, the Ministry of Munitions, or the Education Minister, that steps should be taken to provide a proper succession of student aeronautical engineers, so that the industry may not fail to have men with proper mental equipment.

It all boils down to this. Are we to have a comprehensive and statesmanlike national scheme or a lot of parochial schemes?

Mr. R. Borlase Matthews remarked that if this paper could be amplified in any way, it would only be by laying more emphasis upon the development of the imagination and the applied study of human nature—two most vital factors that are often overlooked in an engineer's training. A really good imagination, he said, is of the utmost importance to a technical man, and needs an experience to develop it, that is outside the curriculum of an ordinary college. Imagination can be closely coupled with foresight, which makes all the difference to success or failure in after life. One of Professor Perry's practical ideas concerning the cultivation of the imagination was the necessity for the embryo engineer to give some of his attention to literature and art. He laid considerable stress, for example, on the reading of good novels—an undoubted stimulant and developer of the imagination.

The great value of a works experience in the earlier period of a man's training, is that not only does it make him a better engineer by throwing him on to the practical side—*i.e.*, thus giving him an intuitive idea of practical engineering facts at a most impressionable period of his career—but also because it brings him into friendly contact with and gives him an insight into the characters of the class of men that eventually he will have to control. Such an experience will undoubtedly justify itself in later life, for not only has an engineer, as set forth in the quaint language of the Institution of Civil Engineers, "to control the forces of nature," but further, he must have a good idea of certain states of human nature which have to be effectively controlled at the same time, if he is to be reckoned among the really successful engineers of his day and generation.

(*Communicated.*)—Professor Perry once made a remark to the effect that any son of Gibeon who likes to stick up a brass plate can call himself an engineer, in which statement there is more truth than at first meets the eye, for as there is no recognised standard of training for an engineer, it is up to each man to get the best possible advice and decide for himself what course his training must take in order to prepare himself for meeting the inevitable competition of later life. A great deal will depend upon his own ambitions and desires. "There is always room at the top," says the old adage. To reach there means a lot of hard work, but the way can be made easier by choosing the best training. The ideal system seems to be, first a good public school education up to the London matriculation standard (especially as this certificate stands a young fellow in such good stead, should he eventually change his plans of life). This might well be followed by such a general scientific course as is set forth in the first year's work at the

Northampton Polytechnic. Then three years should be spent in a mechanical engineering workshop to gain experience, preferably along the lines prescribed by the late Sir Joseph Whitworth, as qualifying for his scholarships. This workshop training should be coupled with attendance at evening classes (in moderation) and engineering institution meetings, also by the regular reading of an engineering journal. This three years might be followed by a year's more advanced mechanical course at a leading technical college. Thus a sound mechanical engineering basis has been laid that will serve for any specialisation later, in almost any branch of engineering. Circumstances alter so quickly in this world that few men on leaving school, who wish to be engineers, can foretell their exact eventual sphere of work, or even if the course of training they set out to accomplish, will be completed. Hence the necessity for each stage of the training to be complete in itself and of the utmost practical value from the point of view of possible after conditions. Undoubtedly the man with workshop and evening class training has the advantage over another with college training only, though obviously it is best of all to combine both experiences.

The one year's mechanical course at college could be followed with advantage by a third year, when a specialised course, in the particular branch of engineering desired, should be taken up.

Vacations should be spent, where possible, abroad. On leaving college a drawing office should be entered for not more than six months, and then a look out should be kept for the opportunity of a post as a technical assistant. It is at this point that the struggle begins for the man to prove that he is in some ways different to his fellows, and it will need all his resource. He will be greatly assisted by working abroad for a time, as this will remove many insular technical prejudices, and give him an invaluable and broader outlook on life. All through his career he will find that he will best help himself by helping others, and he will derive much benefit from lecturing to evening classes, attending and taking part in the meetings of the engineering institutions, writing articles for the technical Press, etc. Above all, he must bear in mind that he has always to create his job, if it is going to be anything of real worth—the automatic technical calculating machine that does as he is instructed is so easily produced that there are too many of him, so that, in accordance with the inexorable laws of supply and demand, his remuneration is correspondingly low, and likewise his rank.

Mr. A. S. A. Ormsby: It is satisfactory to know that ample provision is to be made at the Northampton Institution for the experimental side of the work of training students in aeronautical engineering. In the discussion little has been said about this aspect of the case. Mr. Bairstow modestly omitted any mention of the splendid experimental work that has been done by himself and his colleagues at the National Physical Laboratory. In my opinion students should be made to recognise that experiment is more than an adjunct of mathematical work, that it is really an independent mode of investigation, and that one of its main values is this—that whereas the mathematician goes straight towards the end of his problem, looking neither to the right nor the left, the experimenter is continually on the look out for side issues. He carefully examines, so to speak, the bye products and the residues. Sir Isaac Newton, great a man as he was, just missed several other magnificent discoveries which undoubtedly would have fallen to his credit if he had been as assiduous in his experimental as in his mathematical work. If, for example, in his investigation of the solar spectrum he had varied the shape of the orifice in his dark chamber and tried the effect of a slit instead of a round hole, he would have been master of the Spectrum Analysis, and we should read now of the Newton Lines instead of the Fraunhofer Lines. Faraday's work in electricity needs no comment.

I have recently had the privilege of glancing at a very extraordinary book which is out of print, Grove's "Scientific Method" (I am not sure of the title), printed shortly after the Franco-German war of 1870. I have not had time to

read it thoroughly, but from what little I saw of it I got the idea that it was a book which should be reprinted in the national interest and taught in all our schools. Dr. Walmsley will no doubt be familiar with it, and if he thinks as highly of it as I do he will perhaps consider the advisability of bringing it to the notice of the Education Office as a work of national importance.

I conclude by congratulating the authors of the paper on the interesting statement of the very important work they are inaugurating at the institution.

Mr. C. E. LARARD, in reply to the discussion, said there was a good deal of diversity of opinion on the subject of whether the education at a college or University should take precedence of the works training. He did not definitely pledge himself to the opinion that under all conditions college training should precede the works training, but at the Northampton they had had a large and extensive experience of the " sandwich " system and were convinced that it was a thoroughly good one, though they did not say it represented the last word. He was in full agreement with what Mr. Bairstow had said. It would make Colonel de Villamil's heart rejoice to see the way they taught mechanics at the Northampton. Lieutenant Thurston had, he thought, rather misunderstood the reference in the paper to failure under fatigue. The authors were well aware that a large amount of work was done in connection with fatigue of material. Some of the most important had been done by Mr. Bairstow. The impression the authors meant to convey was that very little consideration had been given to the failure of aeroplane parts—complex parts—due to the fatigue in repetition stresses on those parts. They were rather referring to the built-up parts. He had been struck by the weakness of parts submitted for test. He had tested aeroplane parts that had been designed and redesigned half a dozen times. The dynamic forces and constant jarring when the machine went up must be prejudicial to it, and there should be an ample margin of safety. He was prepared to admit, however, that perhaps something had been done which had not yet been published.

The CHAIRMAN moved a vote of thanks to Dr. Walmsley and Mr. Larard, and this was carried *nem. con.*

The thanks of the meeting were tendered to Mr. Berriman for presiding.

The authors write in further reply to the discussion that their object in reading a paper dealing with the training of aeronautical engineers was not only to set out the present educational requirements of a new profession, but also to anticipate developments in the near future. It was in this connection that they ventured to refer to certain matters of detail relating to recent and pending researches, and their remarks were made with the full knowledge that much recent work done in the directions to which they referred could not have been published, as some of it was necessarily of a confidential nature. Mr. Bairstow's epoch-marking researches on the fatigue of materials, published and worthily recognised by the Royal Society, as well as the fine work in aeronautical research which he is doing at the National Physical Laboratory, were not overlooked and should receive the careful attention of all aeronautical engineers. Dr. Thurston however missed the point of their remarks on the necessity for further experiments on repetitions of stress, as these remarks had no reference to the well-known and published experiments of this nature on actual materials, but rather to needed experiments on the effects of repetitions of stress upon actual parts made up of different materials and put together in the form in which they were proposed to be used, or were actually being used.

The authors were interested to learn that the syllabuses attached to the paper, which are the outcome of the work which has been going on at the Northampton Polytechnic Institute since 1909, are similar to (for of course they cannot coincide with) a syllabus used at the East London College. They presume Dr. Thurston is referring to the aeronautical laboratory work which alone appears in the College

Calendar for 1916-17, but which only represents a small part of the scheme of training for aeronautical engineers which the authors outline in their paper.

It may not be irrelevant to remark that the lectures given by Mr. G. A. Burls at the Northampton Polytechnic Institute stimulated the production of a book by him on aero engines, which is recognised as the standard work on the subject.

Mr. Henry Fowler's remarks as to the urgent necessity for training senior students to replace the almost irreparable losses which have occurred at the Front were dealt with by one of the authors in acknowledging the vote of thanks. A joint paper read by the same authors before the Institution of Mechanical Engineers in December, 1915, called attention to the urgency then of taking steps to supply the deficiency, but the result has been such as is accorded to voices crying in the wilderness, and at the present moment the whole of our technical colleges are denuded of senior students with the exception of a negligible number largely composed of foreigners, with a very slight sprinkling of English students, some of whom have been invalided from the Front. One of the results of the present discussion should be a revival of interest and endeavour in this direction.

The authors are keenly alive to the necessity, referred to by Mr. Fowler, of offering good salaries and prospects as well as congenial work in the direction of research, so as to secure men of the right type as engineering teachers. They are also keenly alive, as was stated by one of the authors in reply to the discussion, to the defects of many modern text books dealing with the subject of mechanics.

Several of the speakers emphasised other aspects of the subject to which at this juncture it is unnecessary to make further reference, but which the authors venture to hope will not be lost sight of in the educational readjustments which will be under discussion during the coming winter.

FIFTH WILBUR WRIGHT MEMORIAL LECTURE, 1917.

The Fifth Wilbur Wright Memorial Lecture was delivered at the Grafton Galleries, Grafton Street, London, W., on Wednesday, June 13th, 1917, at 8.0 p.m. The chair was taken by Major TOWNSEND F. DODD, Chief of Aviation with the United States of America Expeditionary Force.

The lecture was entitled, "Looking Ahead," and was delivered by Lieutenant-Colonel Mervyn O'Gorman, C.B.

Major DODD: Ladies and Gentlemen,—It is with a great deal of pleasure that I accepted the honour of the chairmanship of this meeting, the more so as General Ruck stated, it comes at a very psychological moment. We have just joined with the British and French and other Powers in the greatest war in the history of the world. We feel in the States that the war is going to solve the problem of aircraft. It appears to me very fitting that as the representative of the Military Aviation Section, I should have the pleasure of being present at the Wilbur Wright lecture in London. I have not had any time to put my thoughts into any crystallised form, so I take leave to ask Colonel O'Gorman to proceed with the lecture, hoping that I may be able to obtain some ideas from him.

Lieutenant-Colonel O'GORMAN: Mr. Chairman, Ladies and Gentlemen.

1. I thank you and the Society's Council for the invitation to deliver this the fifth lecture in memory of Wilbur Wright, the man of foresight who gave 12 years of his life to unrecognised toil and who is now, after a further 10 years, fully acknowledged as a far-seeing and sane experimenter. We are proud that he was a member of this the earliest of all Aeronautical Societies of the world, and we hope to carry to yet greater things the consequences of his great achievement. To do this we must now and then look ahead.

2. For nearly three years aeronautical engineers have been working under intense pressure on a multiplicity of details of design and production. Many have thereby been forced away from their normal wide outlook and habit of detached thinking—unless fumbling for a 'bus fare be a mode of thought. Our minds have been moving forward as strap-hangers are moved forward by the train amidst an intolerable crowd of immediate calls, while the general survey of the horizon—the trend of the past, the prospects of the future—has been obscured by the crowd.

3. I will not say that "aeronautics is in its infancy"; that phrase comes up like a cork, and also produces the effect of a cork which fails to pop, the suspicion that there is no sparkle to follow, but we will consider that demand for foresight which is made by the world upon the engineer. The engineer himself omitted it from his definition of his functions in 1827, and has continued to omit it ever since that date when the Charter of the Institution of Civil Engineers was drawn up. Yet it is the most insistent call we have to meet, amounting almost to a demand for prescience.

4. It was General Scott Moncrieff, himself a distinguished R.E., who originated the reply "I am an engineer, not a prophet" when too searching demands were made upon him by the Army Finance Branch as to the outcome of some scheme, and there are few who have had control of engineering works on the larger scale who would not have been glad to get relief from the tax on their prescience, if it could be got, by borrowing this dictum. Every estimate,

tender, specification, contract is such a tax; every design, preliminary experiment, tool, and gig equipment for output is an expression of the effort to foresee the position some six or twelve months ahead. We are now, however, seeking an outlook over a wider gap than this, so let us step back to spring clear.

5. Aeronautical engineers have lived for many years on a diet of hope, exercising their imagination and stimulating others to look ahead; hence they can realise with exceptional clarity how foresight may become dormant in busy men and so be led to ask themselves, "Now that we are busy, are we as wide awake as we were?" "Do we now pause to look 10 years ahead as we used to do?" I believe that until Mr. Holt Thomas's lecture the answer from the aeronautical world at large was "No."

6. Of course, our aeronautical world includes both the Air Services and also financial persons as well as civil engineers.

In the Services the routine of life calls mainly for the very different mental effort of *rapid decision*. Yet this is not a diametrical opposite, for these decisions will be unsound if there has not been thinking in anticipation, and in war we see how the higher commands are pitched into the "foreseeing business." The military organiser must be among the prophets and not least in the matter of the purchases to determine on.

7. The financier should be par excellence a seer. He deals in credit and in confidence. He should be clear-sighted enough to know when to take a risk. Those who think he would be more useful if he were gullible are deeply wrong; that would be disastrous. What we wanted both from him and from the purchaser in the days of our struggles was foresight. The proof that it was lacking is that aeronautics unquestionably found money and orders too hard to get in the past.* This, on the one hand, arose from the fact (which has in other ways been of priceless service to us in the war) that our banks are mainly engaged in *deposit banking*, rather than in taking part share in developing newly-fledged industries, after the style of the industrial banks abroad†; while, on the other, the Services, who were the purchasers, were and are tied to a peculiar Parliamentary adjunct.

8. This adjunct is another kind of financial person from that first indicated. Aeronautics, military and naval, has been and will be closely concerned with them. These are not courageous "gentlemen adventurers," to use the old phrase; they themselves would say they are the antithesis thereof. Anyhow, the country's money is not entrusted to financiers in the usual sense—a name for those who weigh a risk against a profit and take both. Rather is it in the hands of anti-spending organisms with an astonishing aptitude for evading money risk. In the wider world it is axiomatic that no progress can be made without venturing forth, but we have had no State Department instructed so to venture; indeed it is almost incompatible with the strict annual accountability exacted from Army spending departments in most democracies.‡

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* It is remarkable that we were then investing one-fourth of our national income abroad—our foreign and colonial investment represents about a capital of 4,000 millions (E. Crammond, Inst. of Civil Engineers, March 12, 1917).

† This is no place for developing the contrast between bankers' methods at home and abroad, but for a brief *exposé* of one point of view reference may be made to the "Round Table" of December, 1916. Certain reasons which were, before the war, gradually forcing the German Banks towards the "Deposit Bank" point of view are also there shown. It is something to be the trusted money centre of the world. Nevertheless, the "Industrial Banks" had moved mountains, and we find on May 16, 1917, that a British £10,000,000 "Trade Corporation" has been granted a Charter for some such Industrial purposes (see recent Parliamentary Papers) and is now under hot discussion in the House of Commons.

‡ See "Aircraft Politics in War Time," p. 203, "Quarterly Review," January, 1917.

9. One could quote a luminous address delivered to the Staff College by Sir Charles Harris, K.C.B., the head of all Army thrift for 25 years, to show that to succeed in *not spending* is the gauge of effectiveness for such a branch provided the Army is carried on for the year under review. In view of the object for which his department is instituted he must be right. This, of course, is a different thing from financing a development.

10. It felt different. But we can learn from the past. On almost any tree it is possible to notice that its branches are a diagrammatic record of their early struggles towards the light. Their crookedness is ascribable both to the early errors and the correction of the earlier errors as to which was the best direction to shoot in. They are a record of lost time, of changes of effort, of delays, and therefore to us who may be thinking of an analogy in aeronautics, of regrets.

11. British aeronautics to-day carry just such an impress of primitive struggles and mistakes, and the question arises whether we can learn and whether we are now unwittingly, as we were then unwittingly, misguided by prejudices, our own and others? A point of view is prejudiced when it is held with a tenacity which is in excess of that warranted by the evidence. Let us consider some notions of the past. (See "Aircraft Politics" in the "Quarterly Review," January, 1917.)

12. Memories are so short that our instinct is to deny as a body that we delayed our own progress by early errors of our own outlook, particularly as we were so acutely conscious of, and so busy combatting the errors, obstinacies, and prejudices of others. I can well believe that most members have forgotten the almost unanimous opposition which existed to the idea of forcing up the speed of Service aeroplanes* to the level of the "stunt" aircraft of the time as recently as 1910. Even 75 miles an hour was taboo! A little prior to that there was a fairly widespread insistence upon flying with the minimum possible engine, and one of our British pioneers so far succeeded as to achieve flight with about 10 h.p., a performance in itself a record and highly creditable.† Quite common in 1911-12 was the conviction that flying for an hour at such a height as 4,500ft. (to-day the easy achievement of every junior with less than 20 hours' flying experience) was a monstrous test to impose.‡ You will, I think, sadly recall the wastage of small fortunes on wing-shapes which had no attraction that was even arguable except their singularity§ and the unregulated gusty enthusiasms which at one time favoured all monoplanes to the exclusion of other arrangements,¶ or later still which, in order to favour bigness and twin engines, began to despise the small craft,** or later yet, what may prove to be, a regrettable revulsion against big craft.

13. You may remember the furore for steel tubular construction (I was myself a victim); harmless it might be said in itself, but pernicious in that it was commonly accompanied by a prejudice against the use of wood. There have also been prejudices for and against the rotary engine, for and against pusher aeroplanes, for and against warping wings to the exclusion of wing flaps, etc., etc.

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* I except Mr. Lanchester, and also claim to have escaped this one particular error. See Inst. Auto. Engrs., page 291, para. 75, "Problems Relating to Aircraft," by M. O'Gorman.

† Mr. A. V. Roe, to whom great credit is due for this by no means uninstructive "Record."

‡ But for this error we might years ago have got clear of the main aero-carburettor problems of to-day. It fell to the Author to draft those test regulations, and to the Trade Press to condemn them.

§ The basic trouble here was the disregard of the wind tunnels of Eiffel, and the N.P.L. Prandtl and Riabouchinski.

¶ Notably the tractor biplane to which again Mr. A. V. Roe was the British exponent, and Breguet the French.

** This phase was worse in France than in England, but it was significant even here.

14. It is to be noted that as opinions, zealously pursued and tested, the views in themselves were a stimulus to useful experiments, but the prejudice which was imported against the alternative courses was nearly always narrow and pernicious to our progress and the very reverse of foresight.

15. This brings us to the more ticklish matter of the prejudices ruling to-day. There is a character of H. G. Wells's who says that a young lady's path is "beset with pitfalls prowling about." That represents also the peril of one who ascribes to prejudice what others may have installed as part of their doxy. Let me paraphrase the definition hazarded earlier, that a prejudice (which may be either right or wrong) is a view strongly held upon a weak proof—and proceed to some general examples.

16. I suggest that there is a prejudice in the matter of a low price for labour; it is also held that *destroying goods* is in the interest of trade and good for securing wages to labour. It is a common prejudice to believe that if one firm makes a splendid scientific step and thrives accordingly, that it is bad for others in the same trade. British airships—the 40-hour air-scouts for the Fleet—were killed by public prejudice. There is possibly more prejudice than proof at the root of our neglect to found any hopes on soaring flight. The wind tunnel and its priceless contributions to flight have been decried from prejudice—not proof. The method of trial and error called rule of thumb has been set up as the antagonist to studied design on similar grounds. I believe every exponent of this antagonism is an opponent of progress.

17. There are prejudices against stability, and against the use of factors of strength in aircraft design, and against the possibility of combining controllability with stability. I am told that there are still prejudices against big aeroplanes and on the subject of the best number of engines to instal. Amongst the notable prejudices of the war is one which declares that German aircraft were and are better than ours on the average, class for class, and that the exceptional German aircraft was better than the exceptional British. There have been astonishing prejudices as to the efficacy of certain bomb-sights and the utility of thin armour.

18. There is a wide class of prejudice fostered by catch words, generally detached from their qualifying context—the "inevitable survival of the fittest" is the common example. Thus "competition is good for trade," when unqualified, is a dangerous prejudice of which I hope to give an example (in paragraph 29) later. In technical studies there is a widespread prejudice against "overlapping." I regard "overlapping" as the useful free and independent study of the same subject by different intelligences, and invite you to note that overlapping research is the root of some of the finest engineering advances in industrial life, and of the finest scientific progress, as well as one of the chief excuses for the statement that "competition is good for trade." The word "fog" is in danger of becoming a catch word for prejudice against aeronautical development.

19. I have been told of the existence of prejudice against gravity-controlled air-speed indicators and against a certain oval sectioned aeroplane wire. I believe there is a prejudice against the use of instruments when teaching flying, and run the risk of being called prejudiced for saying so. There was a prejudice against the registration of private motor-cars, and there is danger of one as regards aeroplanes. I am told that there are even prejudices in Parliament—that is to say, conviction in excess of proof—against particular kinds of aeroplanes. You will remember the yokel who remarked as he ground his heel into a useful little creature who could not answer back—"I'll larn ye to be a toad." I have seen similar prejudice against other unoffending workers. None of these things are good for progress. There are outside of this Society, and perhaps within it also, prejudices on the subject of vertical rising flying machines, and

I think there have been recent prejudices on the subject of dope, shock tests for steel, the use of welding, etc., etc.

20. I hope that these few suggestions, even if some of them are wrong, will be taken in good part, for the sake of the moral.* For if any one, and still more if several, of these convictions were erroneous and were to be held to be certainly correct, we should be led to the definite avoidance of a particular line of construction, or performance, or study, and to the adoption of its opposite number. For a brief moment this flush of popularity would benefit the happy enthusiast whose choice was selected, even if he were mistaken, but the kink taken by British aeronautics would react to his and everybody's eventual detriment.

21. We may say that so long as no preponderating prejudice leads us *all together* in the same wrong direction, these prejudices only operate as the varied entnusiasms which make for the more thorough exploration of some corner of our immense field of inquiry and at the cost of some little delay give rise to a very definite new knowledge and certainty. However, it would be a grave lack of foresight not to remember that we are relying upon the mere chance that the lack of interdependence among individuals will save us. When prejudices are rife we are staking our safety on the survival of our own "cussedness"—a very slender safeguard against the "all together" tendency which every socially-united community is more and more drawn to, the more in proportion as it is more closely knit and organised.

22. The remedy, the insurance against this risk, is provided in the existence of the individual constructor healthily overlapping in his studies those of his friends and rivals, and in the free discussions which our Society provides, with occasions for now and then taking stock of our position, past and present, with a broad philosophic mind.

23. I would venture on one example now sufficiently far back in date to be quoted without raising any feeling—of a dangerous run of prejudice from which we have escaped only with pain. I allude to the time when almost the whole British aeroplane industry centred its efforts on the monoplane when it was as possible then, as it is now, to see that the girder structure of the biplane lent to it specific advantages for at least some types of aircraft. It was a rude shock when this mono mania, or monoplane mania, was brought up to a standstill. One of the evils of this is quite possibly the reaction which set in and enabled Mr. Besnard, the French Air Minister, to say lately with apparent satisfaction that he had not got a single monoplane, yet I doubt if he has seen, and certainly I have not yet heard of, any technical study which has established that this compact type of machine has not still got many useful fields.

You are probably aware that a danger nearly as great threatened French aeronautics over the big multi-engined machine as lately as within the war period. They almost stayed all other advances in favour of these large aircraft. Our industry having in each country a sole purchaser, the Government, suffers the risk of an "all together" prejudice more greatly than ever did the automobile or shipbuilding industries with their various outlets and various demands and various supplies of funds.

Neither of these runs of prejudice actually brought the trade to a standstill, but we have herein a lesson which some of those, and they are very numerous, in socialistic centres who believe in the exclusive State control of all capital and industry might usefully take to heart.

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* It is regretted that the reading of this lecture was followed by the reprinting of a misleading attack, amongst other things, on the work of the Royal Aircraft Factory (in the "Aeroplane" of June 20, 1917).

24. This brings us to the great future in which the aeronautical industry will have the benefit of totally independent purchasers—commercial aeronautics.

Commercial aeronautics is bound up with using the values which accrue incidentally to the employment of aircraft. I take three of these:—

A. The speed of transit made available.

B. The directness of the route which can be selected.

C. The utilisation of helpful winds and evading bad weather.

Everyone finds himself confronted with the necessity of knowing even vaguely the possible objects of commercial aeronautics when starting on the subject. This arises from the extremely fine cut qualities of aircraft design, which conduce to specialisation of each machine to a specific purpose. In view of this, it is not wise, I think, to say even that the "weight per horse-power" ratio of the complete loaded aeroplane is a direct criterion of the efficiency of a design, however strongly we may recognise its value. I am not, in saying this, opposing the essential necessity for a clear summarisation of the "weight per horse-power" ratios of all possible sizes and kinds of aeroplanes, together with the performances and other data. We need such summaries for the sake of the light they will cast upon the value of a high horse-power per lb. weight. Commercial aeronautics will not in fact find that the exaggerated ratio of power to weight which is so useful for war reasons will be demanded for peace uses; it is to settle this point among others that the summarising work is needed, and that at an early date, and for the benefit of all.

It is then a matter for study to determine—(*a*) What is the amount of gross weight that may be safely entrusted to a given or available B.H.P.

(*b*) What is the amount of gross weight that may be safely entrusted to a given wing area as both will differ according to the class of usage. The Aëronautical Society and S.B.A.C. Joint Committee is asking for funds and powers to co-ordinate this, which is the information on which the thinking process of the designer must be based.

For transit over a district in an aeroplane which is not exposed to attack from land guns or pursuing aeroplanes there appears to be no urgent need for phenomenal rates of climb in certain, and probably in most, commercial classes of craft. All commercial work will however require some rate of climb yet to be determined, which is the minimum which is safe for overland work on the one hand and oversea work on the other. In a country of small spaces like Britain the distinction will be marked—in wide open lands the two will approach one another.

To make the idea concrete, 500ft. per min. climb from ground level is a possible safe figure over England, while much less is safe over sea.

Whatever the figure, once this is achieved, any further climbing ability would be got either for some particular reason or would be got only by the accident that the demand for engine power arising from the *speed* desired gave the extra climbing ability.

One of the matters which the student of commercial aeronautics is concerned to *establish at an early date is, what is the minimum safe climbing rate* under the two broad classes?

A. Over Britain (or country of such small alighting areas).

B. Over sea (or large spaces).

A good deal of information on this could be collected from pilots *now*, and any bureau formed by the Civil Aerial Transport Committee could thus be informed.

Next, given that the minimum climbing ratio is secured, we shall find that some of the designs will be needed.

(*a*) For high speed expressly.

(*b*) For weight carrying.

(*c*) For long distance work (which does *not* make quite the same demands as weight carrying for short distances, notably because low head resistance is cardinal in C class).

(*d*) For intermediate and special duties.

As soon as rapid climb and quick manœuvring are not demanded, design will differentiate itself from war aircraft. Class (*a*) and (*c*) above will need wing sections like those in war craft where extremely low head resistance is cardinal. Class (*b*), which will no doubt be wanted for war, will differ in its wing sections from the " minimum head resistance " classes. In all cases, since high controllability and quick manœuvring will be far less essential than in war, it will be much easier to get a reasonable factor of strength, which means that an adequate strength may be got with light weight.

We cannot afford to overlook the importance of using the wind, and thus frequently doubling, say, our speed of transit and halving our fuel cost. It becomes therefore a matter of the greatest moment to know at what height to fly to get best economy, *i.e.*, for the minimum total fuel expense, for fuel bills will be enormous.

It is to be noted that height enters into the matter in a far more serious way than in relation to the mere extra fuel needed to *climb* to the height for the journey. There is the extra fuel expended in remaining at the selected height, when any such height is desired as requires the machine to fly appreciably cabre, *i.e.*, beyond the " maximum point " on the curve of " lift/drag ratio " of the aeroplane measured as a whole.

This indicates another study, the ascertaining of the height of economical travel with the wind (obviously the height of economical travel against the wind is as low as possible consistent with a safe range of glide to alight).

For the purpose of the study it is necessary to have as large a number of lift/drag curves of completed machines as possible in the first place, and in the second place the lift/drag ratio of the entities constituting these machines, so as to get clearly any correction factor which arises from their assembling and mutual interference, and from scale effect.

I am aware that I am putting forward a programme of very great extent, but if the country is to take the air *and keep it*, the sooner these matters are fairly faced the better.

Commercial aeronautics is clearly one of the subjects to which I have alluded as requiring foresight, technical, political and financial. Broadly, the objective is simple, in detail it is very complex. This at once suggests analysis as a help towards foresight.

Commercial aeronautics can be divided into three parts :—

(*a*) The home or internal aspect.

(*b*) The foreign or international aspect.

(*c*) The Imperial and Colonial aspect.

The internal British question can be resolved into five separate subject-matters for study, and as each of these has sub-heads, I tabulate as follows, drawing attention to the two main heads—(1) the production, and (2) the utilisation (or " aerial transit ") problems, corresponding roughly to supply and demand.

25. TABLE A.

Internal (British) Aeronautics.

The Uses of Aircraft.
(*a*) Transit of goods.
(*b*) Transit of letters.
(*c*) Transit of persons.
(*d*) Labour of transit service.
(*e*) Finance of Trans-aerial Coys.
(*f*) Government subvention of aerial transport.
(*g*) Private, sporting, and domestic use.
(*h*) Scientific use, surveys, etc.

The Safety Provisions.
(*a*) Aerial routes and lines of landing grounds, maps.
(*b*) Night flying and landing.
(*c*) Aerology and meteorology.
(*d*) Wireless communication of distress, orders and signals of direction.
(*e*) Labour of ground upkeep, etc.
(*f*) Subvention of safety precautions and grounds.
(*g*) Accidents investigation.
(*h*) Keeping of records.
(*i*) Insurance of (1) pilots (2) passengers (3) craft.

Education of Personnel.
(*a*) Designers and engineers.
(*b*) Flyers and navigators.
(*c*) Military call on flyers.
(*d*) Polytechnic and correspondence schools for labour.
(*e*) Subvention of education.
(*f*) Collation of data, research.
(*g*) Inventions.
(*h*) Consular trade information, etc.
(*i*) Scholarships, exhibitions, premiums.

Production of Aircraft.
(*a*) Best employment of existing factory organisation.
(*b*) Finance and subsidies to makers.
(*c*) Military and naval requirements.
(*d*) Publicity and "load curve orders."
(*e*) Utilisation of overplus of military and naval war orders.
(*f*) Supply of aircraft to foreign Governments and colonies.

Labour.
General Question.
(*a*) Skilled and unskilled.
(*b*) Male and female, including military, wounded, pensioned, etc.
(*c*) Apprenticeship and provision of time for instruction in technics.

TABLE B.

FOREIGN AERONAUTICS.

The formation of Industrial Links. Co-ordinating Technical Societies.	Post Office Reciprocity. (*a*) Prices for postage. (*b*) Methods of collection and delivery. (*c*) Agreed routes.	Post-War Inter-Governmental Agreements (Allied and enemy). (*a*) Flying rights. (*b*) Landing rights. (*c*) Rule of the "road." (*d*) Supply of aircraft to foreign Governments. (*e*) International law, prohibited areas, etc.	Registration of Craft. (*a*) Salvage by ships and by aircraft. (*b*) Exchange of meteorological news.	Customs and Policeing. Quarantine and Aliens' Question.

26. It is best not to discuss these heads till we have also analysed the international and Colonial questions into sub-heads. It will be found that the profitable use of aircraft is based on speed, and that as speed of transit includes door-to-door movements, if there are, as we see at present, considerable terminal time losses, the longer the distance over which aerial work is conducted the less significant are the " terminal charges " upon our time of transit. This merit introduces, for a small country, the advisability of studying flight beyond its borders, and for an island the consideration that shipping is slow compared to the railway or motor-car. Therefore international flying will come up early in our development of aerial transit, and may be expected to concern movements over the sea, not necessarily in seaplanes.

27. But you cannot go abroad without your tickets, your circular notes and passport, so you cannot fly over another country without making arrangements. These arrangements will be easily made if there is a body of opinion abroad which is favourable, which recognises that it will not get landing rights in British Possessions unless British aircraft have landing rights on foreign soil. One of many ways of securing such a body of opinion favourable to aerial transportation in the foreign lands themselves is to institute industrial links between our own constructors and foreign constructors, whether as " succursales " or joint firms, or shareholders, or agents. I therefore put these first and tabulate five sub-heads. (See Table B.)

28. If we develop our aircraft-making and aircraft-using properly we shall be the first to wish that other countries may be equipped with " aerial ways " (lines of landing grounds), aerodromes at big centres of industry, finance, or pleasure. Moreover, we want to find elsewhere not only the maps, but also most of the safety provisions desirable at home. All these things will be fostered by the energies of societies like the Aëronautical Society and the Society of British Aircraft Constructors, which we should like to find abroad and enter into relations with. At present they are not nearly as active abroad as at home. They might be fostered not only officially, but rather through the intermediary of our *industrially-linked firms,* whether for construction or transit.

29. One of the important matters for consideration is the avoidance of cut-throat competition at a time when it is always difficult to ensure a remunerative investment with any certainty. This involves the inter-State provision of what may be termed limited monopoly for certain services—at least, until the businesses are well launched and till statistics exist on which insurance operations can be satisfactorily based. Firms can be trusted to make their own value felt by the Post Office and by passengers whom they desire to attract, but they are defenceless against one another if as soon as one energetic individual has initiated an enterprise the value of his strenuous work is to be poached upon by irresponsible persons (who may, it is true, ruin themselves undeplored), but who may drag into a like ruin those whose industry and courage founded the whole scheme. The Government should step in here in the interest of maintaining what it must maintain, a large successful and enterprising industry.

30. It may here be worth while to say why the country must do this. It is a matter of economy. The Air Fleet differs materially from the Sea Fleet in being more rapidly expendible. No one would dream of rebuilding the British Fleet six or eight times per year of war. Yet the Air Fleet requires at least this. Thus the aeroplane occupies an exciting position halfway between a battleship and a cartridge. To decide on having an Air Fleet for war is synonymous with having an aircraft industry in peace competent to produce some eight air fleets per annum when called upon.

31. The question " What industries are essential to the future safety of the nation, and what steps should be taken to maintain or establish them?" was set

to Lord Balfour of Burleigh's Committee. The reply (though only a general one was given by the Committee) certainly must be taken to include aeronautics not only as a key industry, but as an industry the growth of which is necessary to the formation of pilots and the full maintenance of their "weapons" at the abnormal rate which results from war wastage.

The Committee's reply included the following phrase:—"We consider that special steps must be taken to stimulate the production of . . . manufactured articles within the Empire wherever this expansion and production is possible and economically desirable for the safety and welfare of the Empire as a whole."

32. The necessity for special steps being taken to preserve and expand the production of aircraft is scarcely open to question.

When we seek for what kind of special steps are, on the one hand, likely to win the support both of Protectionist and Free Trade voters, and on the other are sanctified by precedent and analogy, we can probably find suitable stepping stones through the marsh of the old controversies. One suggestion is the subventioning of specific air-carrying trades, postal and other, on terms, so that on the one hand the public gets something for its money and gets a supply of pilots against a war demand, and on the other hand the aircraft producer gets orders.

There is precedent for this in the mail-carrying business, and there are also valuable foreign precedents and analogies.

33. It is obvious that the exclusion of foreign aircraft from the right to alight on these shores is not compatible with our expectation or our demand for the rights of alighting on foreign soil—similarly heavy port dues or landing dues are objectionable—for if we mean to build up the biggest Air Fleet we should probably pay out to foreign Governments the biggest total of port dues even if their scale were the same as ours. It is submitted as worthy of consideration that our interest lies in the direction of the smallest possible alighting tax provided reciprocity is secured or approximated to.

34. This therefore points to another form in which support may be given by the Government to the industry—the relieving of alighting grounds of part of the burden of rent, maintenance, night lighting, etc.—and this can, not improbably, be achieved in such a manner as to secure for the taxpayer the direct *quid pro quo* dear to the finance branches, by providing that a certain amount of accommodation shall remain always available for service pilots.

35. Subvention of aeronautics need not by any means be limited to cash payments as subsidies to producers.

It is amply clear that the formation of a chain of alighting grounds from big centre to big centre, if suitably chosen, may be made so as practically to abolish the risk of forced landings—in the current sense—that such a chain of grounds must be a high source of economy in machines and men to the State which is perennially conducting its air service training and manœuvres, and that the greater our private aerial locomotion business becomes the greater is the money value of such insurances against accidents.*

How to arrange that the owner of the alighting fields shall be able to graze them, manure them, etc., at certain times, or otherwise to derive value from

* I was fortunately instrumental in bringing to this country the first record of such an aerial way in practical use in Italy, and in securing from Major Perfetti the Italian maps which our recent lecturer, Mr. Holt Thomas, used as a striking illustration of his lecture. Aerial ways from Turin to Milan, to Udine, and from Milan to Rome, down both sides of the coast form part of the scheme. Recently we learn that the Central Powers are starting a £2,000,000 scheme—Berlin, Constantinople and the East.

them without imperilling the flyers in any way, together with the institution of suitable markings, is a matter for careful study, and such study will no doubt be conducted by using to the utmost the existing organisations such as this Society and its ally, the S.B.A.C.

36. It is certain that an industry sufficient only to build the aircraft needed by the Services in peace time cannot possibly be large enough or "live" enough to meet the heavy depreciation of war, even at the outset, or even for a short war.

The established Army system of keeping a "mobilisation store" of goods which are for ever untouched, and are kept in readiness and up-to-date for the emergency of war, is not applicable in its simplest form to an apparatus so quickly antiquated and so rapidly perishable, even when not in use, as an aeroplane. Hence large constructional works must be kept in being, and they can only be kept going economically by being profitably employed, and this in turn demands that there shall be a full "turnover."

So soon as this is known to be decided on capital will flow into both the aircraft production industry and the aircraft transit industry from all sorts of private channels, to the great profit of the State.

37. One way of securing this "turnover" has been indicated in the supply for "transaerien" companies; another is the supply of craft to foreign Governments, much as we supply battleships or guns in time of peace. What we owe to this policy in the matter of shipbuilding is almost unthinkable. The business of assisting the aircraft producer to this end is one which calls for the wisest and most far-seeing policy—one step at least of this policy is in our hands.

The shortsighted and ignorant booming of German machines should be stopped now, not arbitrarily, but by the simple dictates of truth, and if for no other reason, to avoid discouraging our flyers at the front.

The Commercial and Postal Uses of Aircraft.

38. As we have recently had a suggestive paper on aeroplane transport, giving rough costs on a certain route, I will not dwell on it save to recall the existence of the airship and to touch on one matter which I raised in the discussion, and to which Lord Cowdray also addressed some remarks. I allude to the danger of the hiatus which might occur between the war demand and the peace demand. There appears here all the value that attaches to promptness in giving —"*bis dat qui cito dat*"—and all the difficulties that attach to the exercise of foresight.

In another sphere we know, that to secure the return of soldiers to the land, a Parliamentary Commission has already recommended that immediately on the declaration of peace 20,000 cottages shall be built at or near the land the soldiers are to till, thus utilising the building skill now in the ranks and starting the homes for our men on the land. So far as the housing of workpeople near centres of aircraft production is concerned, this may be said to have been largely provided during the war; what has not been foreseen even on paper with a like definiteness is the absorbing of our aircraft output and the incidentals thereto. The financing and laying out of the specific postal routes, the location of the mechanics, repair men and tuners at the ports of departure and arrival, the housing of aerodrome officials, groundmen, accountancy clerks, the motor car service from town to aerodrome, the purchase of land and the establishment of title, the preparation of lists of flyers who may desire to find occupation at once instead of losing their skill by many months inactivity, the preparation of such drawings as may quickly allow of adapting war aircraft designs to their new uses, and the designing of such new weight carriers as may be more suitable to transport work; some or

all of these things are needed if the industrial organisation of the factories is not to crumble during a long *hiatus*. Six months of idleness will disrupt any factory organisation and will lead to the paying off of workpeople and their consequent suffering and discontent. This six months of idleness must not occur.

39. Lord Cowdray's outlook, the more valuable since some kind of air ministry seems inevitable, and indeed most desirable after the war, was most sympathetic, but he saw and expressed the difficulty. One would like to feel assured that there may soon exist in the desks of private organising companies, brought together *ad hoc* under his ægis, a set of non-clashing plans of campaign on paper, in such detail as to be promptly workable. It is not necessary, but it would be useful if even the names of the intended personnel, most of which is of course with the colours, were laid out ready for the call to man the commercial, postal, wireless directional and incidental automobile and repair services.

40. It must be admitted frankly that the preparation of such schemes is not only laborious, but dishearteningly dependent on circumstances beyond the control of the organiser. Still, just as in peace time we work out complete plans for war conditions which might arise, so in war time we do paper work for peace conditions, even if some of that paper work is wasted.

41. We have had one skeleton scheme to awaken the imagination, but we must have many to save the situation. We are confronted with the position that the mere housing of one month's output of the aircraft builders together with the returned war stocks, as soon as the rapid wastage ceases, is a matter of intense difficulty. Thus we are led to formulate the desire that sales of military aircraft to foreign countries, colonies, private users, exploitation companies at home and abroad shall be as prompt as they can possibly be made by every exercise of forethought, subject only to the retention of such devices and machines as are reserved by the military authorities for special reasons.

42. The policing of the air, though eventually a means of using a number of armed aircraft without appreciable alteration, can only at first consume aircraft on a small scale, however carefully such a scheme be laid out for expansion when the trade develops. It would be putting the cart before the horse to provide for more police than there are potential malefactors, or to provide for enforcing the "rules of the air" on a non-existent traffic.

Safety Provisions.

43. It is paradoxical to say that safety provisions, such as I have outlined, provide some of the most perilous of our subjects for foresight. There is no truer proverb than the French one which calls "la prudence, la plus triste des vertus," yet all administrations revel perforce in the gloomy business. They are egged on, in England particularly I think, by the "grandmother in the street," who unsparingly scourges as government negligence any tolerance extended to venturesome enterprise. The example is to our hand. No car can be sold that cannot break the law, no user exists who does not break it, but the law remains at 20 miles per hour—lest there should be accidents and our parliamentarians be beaten with scorpions. We must stand by and pray that a more reasonable scientific and liberal spirit may infuse our aerial safety code and our Board of Trade regulations when they appear.

Education of Personnel.

44. Technical education is, as we all know, one of the main activities of such an institution of aircraft engineers as our Society represents, whether we act directly by lectures and degrees or indirectly by premiums and scholarships and by effectively driving home the question of correspondence schools, technical classes, and university studies. The limit of this class of activity is for us the

limit of this growing Society's membership and funds. The training of pilots was the subject of General Brancker's opening lecture this session, and both the army and navy have been very liberal in allowing officers to give us of their best; the Council has shown its enthusiasm for the work and the members by their crowded attendances have shown that they mean it to carry on.

The Future Production of Aircraft.

45. The whole of this lecture is directed to secure this end, and I will pick out only one of the sub-headings in my Table A for special explanation, namely, what I have called "load curve orders."

The bugbear of any production is the uneven distribution in time of the orders received. The intolerable burden of keeping a staff and a system to give a large rate of output for a short time and at short notice should, if possible, be put an end to by foresight. The Government will necessarily have certain orders of its own to distribute, and if it be found that, like the motor car trade, the industry is fed by a "season demand," then the Government orders might, if possible, be distributed at such dates and in such a way as to even up the load curve.

46. I do not pretend to detail the good or bad effects which would result if the Army, Navy, Post Office and Transaerion companies and foreign and Colonial Governments all invited tenders on the 2nd of April and placed the whole of their orders on the 2nd of May, to the gorging of the lowest tenderers and the ruin of those who made correct estimates, but I do suggest that there existed no organisation prior to the war for appreciating the factory point of view in the distribution over a period of time of the business of ordering, and I also suggest that any industry with a first class chance of a steady turnover has also a first class chance of supplying an article at once profitably and cheaply—two terms which cannot always be justifiably found in juxtaposition.

47. **The Labour Question** is involved in this same consideration for the same reasons. The process of working "ca-canny" with a view to keeping in his job or making jobs for others is by far the most widespread economic mistake of the labouring class. The labourer's desire for his share of wealth is no doubt accompanied by the knowledge that it must be produced to be distributed, but this is over-shadowed by the conviction that the firm may fail to get more orders, that a lull may come and that he can extend the period of activity between the lulls and secure jobs for his friends by working dead slow. Abolish the lulls and your thin excuse for slacking vanishes. I can only put the question, "Is it beyond the wit of man to level up the load curve?" I think not. Strikes and trade disputes are a separate question on which I do not touch.

Customs.

48. It seems to me that a trading aeroplane can cross a frontier unseen either at great height or by using clouds or at night. It can drop packages at spots pre-arranged with confederates, and can without alighting either return to its own land, or continue upon its through journey and escape being identified by a Custom House officer almost any night of the year.

49. In November, 1913,* a few remarks were made on the subject of customs, and it was pointed out that a Customs' inspection of the contents of aircraft at the time of departure on behalf of the country of call was unthinkable, while inspection on arrival, or on dropping goods, involves all countries in having Custom House

* M. O'Gorman. The AERONAUTICAL JOURNAL, pp. 27-28-29 in discussion before the A.S. of Mr. Wallace'spaper on "The Right to Fly."

officials over so large a part of their surface as to suggest that the number of officials would be excessive. Britain is in an exceptional position, its Custom House has some 8,000 officials all over the country (as the Board of Customs controls all indirect taxation), while the number of dutiable articles is very small. Hence, in this lecture we must base our ideas on the difficulties likely to be raised abroad. I think it may be decided to be impracticable and conducive to the stifling of aeronautics to make it obligatory on all entering aircraft to concentrate upon some agreed ports of entry. Such a concentration would be highly inconvenient and the delay of alighting would be contrary to the very first desideratum of an air service—speed. It will be time enough later to consider the control required over aliens who might enter or over diseases subject to quarantine.

50. Each arrival aerodrome would be liable at times to become a pandemonium of delayed and angry aeronauts. But there are other objections. One would hope to see journeys navigated on a course specially selected to utilise the enormous advantage of favouring winds, and minimise the delay and expense imposed by contrary winds, and therefore such journeys should be planned without the hampering influence of arbitrarily imposed places of call. These plans would seemingly be liable to alteration in the air according to the wind encountered, so as to obtain the best economic results. It will assist in making aeronautics a wealth-producing industry instead of a burden to the State if it is possible to secure that through journeys be made, when desired, without any compulsory stop across one country to another. A significant objection to any alighting for the purpose of Custom House inspection is the probable unfairness of a rule which would be easily evaded by the unscrupulous and which would be very costly to enforce even if the sporting smuggler were no longer with us.

51. In this tangle of difficulties there is a plan suitable for the first few years which has certainly the merit of simplicity, though probably no other, namely, that all airborne goods should be free of duty; treating whatever advantages thereby accrued to the aerial transport companies as subvention in aid. For such a proposal this at least can be said that the British community would not be unfavourably placed since almost every known commodity is taxed more highly elsewhere than in Britain.

52. In the contrary event of a decision to levy duty on airborne goods we must consider the suggestion of a Customs police mounted on fast aircraft to pursue and watch traders.

There are many difficulties about doing this, they are probably even greater than those which are involved in a civil aerial police which we probably must have.

For Customs purposes it would be an anachronism to shoot down a suspected smuggler at sight; we cannot board an aeroplane in flight, nor can we know whether he is carrying sufficient hours' fuel to be capable of outdistancing our policeman, moreover his chance of giving his pursuer the slip by using the shelter of clouds and darkness is quite considerable.

53. At first, at any rate, it may be best to accept airborne goods untaxed; the class of substances carried will only be those of light weight, or of high value for weight, and of these mostly the ones which derive some advantage from rapid transit. In England we should be chiefly troubled by jewellery, saccharine, tobacco, tea and cocoa, and I doubt if these would amount to a serious difficulty.

We should of course be envisaging the issue of an indirect subsidy of an amount not easily knowable, but on the other hand we should economise on what promises to be abnormally heavy costs in collecting the duties imposed. The competition with taxed seaborne or landborne goods would not perhaps be very serious if we remember the greater cost both of transport and insurance when borne by air.

54. As to the importation of foreign aircraft themselves, this is more easily controlled, because it involves alighting. It has been suggested in paragraph 33 that no preferential landing changes be made against foreign trader aircraft under certain circumstances of reciprocity, and accordingly an interval of stay in a country in excess of some preordained period might constitute importation for taxation purposes or alternatively the Gordian knot might be cut, and preferential encouragement given to our own aircraft (as war necessaries) on the basis of a bounty to aeroplanes built in the country and so avoid attempting the alternative of a tax on imported foreign aeroplanes.

Enemy Aeronautics.

55. Mr. Horace Darwin,* in a previous Wilbur Wright lecture, showed us the value of what he called "*inverting*" a mechanism with a view to its better understanding, thus often evolving either new results or suggestions for the solution of what previously seemed very difficult. The Gnome engine with its rotating cylinders might be called a classic example of "inversion" applied to the petrol engine. The bedside clock whose dial is rotated past a fixed pointer is an instance of a more popular kind which also has an aeronautical interest since it is utilised in almost every barograph.

This process of "inversion" can be used and is illuminating when applied to many war proposals entertained on behalf of one side which judges itself to be approaching to victory over the other. If the Germans had practised this they would have seen the comicality to us of their morning hate movement, already indeed discredited among intelligent Germans,† they might have appreciated the recruiting value to us of their early Zeppelin raids, and the pernicious world effect for themselves of frightfulness in Belgium and under the sea, however useful to them for awhile.

56. It has been suggested as obviously desirable after the war that the Central Powers should be for ever restrained from aerial activity or alternatively from any access to Allied landing grounds. Such a proposal should be examined in the light of the inversion process. It was, I think, Mr. J. Swinburne who said that whenever a proposal is described as obvious to the meanest intelligence that is a sign that it calls for careful scrutiny by those of better ability. I am told that the overland aerial route to India, via the territory of the Central Powers, appears to offer special advantages, if I correctly interpret a conversation I had with Lord Montagu recently, and I think he has studied the point; at any rate, until matters of this sort are very much clearer than they are now, it would be most unwise to lay down as fundamental desiderata notions which are only founded on our present bellicose attitude towards the enemy and not on a scientific appreciation of the results involved. At least we may be sure that the very last thing we want is to ensure for the Germans the exclusive use of the easiest aerial run to India and the East.

57. For Imperial and Colonial aeronautics it would be suitable to repeat the same table as was shown for purely British questions, with the introduction of widely different and in some cases very promising aspects due to the greater distances, the absence of postal facilities, the great expense of land transit, the absence of roads, the unexplored and unmapped and unsurveyed regions, and sometimes the peculiarly regular atmospheric conditions. There will be found advantages for rapidly conveying administration officials to points of temporary interest or trouble. The labour question also requires special treatment and so do the conventions for inter-communication between the Colonies themselves and with the Motherland.

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* Horace Darwin, F.R.S., AERONAUTICAL JOURNAL.

† Alec. W. G. Randall, p. 750, *Contemporary Review*, June, 1917.

58. Here is an immense programme for foreseers and prophets. I believe there was for a moment a slight tendency to prejudice against the formation of an Air Board Committee to inquire into the matters which I have here suggested as a suitable field for foresight, but I now believe that since the first meeting, under Lord Northcliffe, this preliminary doubt has in large measure been dispelled. Whether the Aerial Transport Committee, now sitting, on which this Society is ably represented by its Chairman, General Ruck, C.B., solves all these problems or not, we can feel at least that there exists somewhere a somebody who will make an effort towards the elucidation of some of them.

Major DODD: I have been asked to say that on the occasion of the Wilbur Wright lecture there will be no discussion. I wish to state that it has been a great pleasure to me to receive an intimation that London is already preparing for after the war, especially with regard to aeronautics, and I am sure that the Colonel has gone into the matter very deeply. There are several points which appear very important to me. There is a great deal of care and a great deal of thought being used in America to-day with regard to the formation of aviation, not for the distant future after the war, but for the immediate future, based on war conditions. We have not had occasion to consider the utilisation of large aircraft factories after they have served their wartime purposes, and the subject is a new one to me. It has been so completely considered that I feel confident that a great deal of consideration has been given by the best minds in London, and I propose that a vote of thanks be given to Colonel O'Gorman for the presentation of this subject.

Lieutenant-Colonel O'GORMAN: I have not had the occasion to say what I wanted to say, and that is what a pleasure it is to me to see Lord Sydenham's place taken by the young and charming American officer who has come here to-night. General Ruck had the brilliant idea of asking him to come and take the chair. I am sure we feel very glad that he was able to do so.

Dr. R. MULLINEUX WALMSLEY: Our President has asked me to move a resolution which really requires no recommendation whatever. The resolution is, of course, quite obvious, that we record our very heartiest vote of thanks to Major Dodd for his presence here and for his kindness and courtesy in taking the chair to-night. It gives me very great pleasure, personally, to have the honour of moving this vote of thanks, because I find out that I have visited the town from which our friend on the platform has come. I had the great pleasure of visiting it when making some investigations on education, and I have at the back of my mind some very charming recollections of happy days spent there. It adds to my pleasure to have the honour of offering our very great thanks and our most cordial welcome to him, and to his colleagues in this country for coming to us with an effective organisation which we are all perfectly certain will have a great effect on the war. We welcome you very cordially and we wish you and your colleagues every success in your efforts to help the countries of the Old World with the enthusiasm of the New World.

Major DODD: On behalf of my colleagues and myself I desire to thank you for the spirit of fellowship with which you have received us, and the courtesy you have extended to the American forces that are now allied with you.

OBITUARY.

THE LATE MR. HORACE L. SHORT.

The Services, the science of aircraft design, and the industry of seaplane production have sustained an irreparable loss in the sudden death, on April 16th last at his residence in the Isle of Sheppey, of Mr. Horace L. Short, the eldest of the three brothers whose products are known the world over.

Though only 44 years of age the late Mr. Horace L. Short crowded as much into his life's work as would have sufficed for the careers of half a dozen ordinary men. Whatever he undertook became forthwith a medium for practical pioneering on his part. Long before he gave his attention to the proposition of aerial navigation he had furnished many proofs of a remarkable originality combined with that even more rare quality, the ability to think and act in practical terms.

To say that we owe the British seaplane industry to his foresight and genius is almost to understate the case, in that to-day the influence of his work spreads far beyond these islands, and even the Empire. Born in 1874, he was educated at Risley Latin School, whence he proceeded to a course of engineering training in the shops of the Stanton Iron Works, Notts. Subsequently he was at Evlin Compton's Works at Chelmsford, and later at Chatham Dockyard.

His love of the romance of life, as well as the spirit of adventure that is inherent in all pioneering natures, soon induced him to travel. In the issue few men have voyaged more widely or done a more various share of the world's work. Only at rare intervals could one induce him to recount any of his experiences. They were never for the ear of strangers; nor were they ever told for telling's sake, but only to illustrate some phase either of human nature or of human enterprise. He never seemed to think that there was anything remarkable in himself, all his wonder being absorbed in the marvellousness of this world. He was a man not content merely with looking at things. What he saw he pondered deeply, with the result that, if he had elected to commit his views on almost any subject of human interest to paper, the world would have been the richer for fresh and eminently helpful ideas.

His first long voyage was to Australia in a sailing ship, a mode of travel of which he had much subsequent experience and which always fascinated him, despite the fact that on many occasions the risks he ran in strange seas were such that few men would care to share. In Australia he undertook various contracts for sheep shearing machinery. Next he went to the South Sea Islands. There he was captured by cannibals, a chapter of his life's history which, if told in detail, would thrill schoolboys throughout the Empire and make many superior persons well-nigh incredulous. On his escape he returned to Australia. Afterwards he visited China, whence he proceeded to San Francisco, where he was engaged for a while in putting machinery into ships.

His next venture was in connection with a large silver mine in Mexico, called the Panuco. Here he worked as Chief Engineer for four or five years and, despite all difficulties in his path, succeeded in introducing air-compressed machinery driven by water turbines, thereby revolutionising the whole manner of working the mine in question.

It was at this period that he made experiments with the articulating syren, otherwise known as the Auxetophone. He made such progress that he returned

to Europe for the express purpose of developing the invention, bringing it to a fair pitch of perfection after devoting some months to it. The tale of grand opera being rendered to the ever-receptive Parisian public from the top of the Eiffel Tower by this means illustrates one only of many developments that Horace Short loved to introduce, quite anonymously, alike to civilised and to savage life. In the meantime his restless nature caused him to visit the Ashanti Gold Fields for three months. Contracting fever, however, he was fain to return to the old country, where he continued experimenting with the Auxetophone and also assisting in certain experiments with printing machinery.

As a result of this work he joined Sir Charles Parsons at Newcastle, assisting him in his experiments with steam turbines, among other even more romantic matters. It was while engaged on this work that his two younger brothers, Eustace and Oswald, invited him to join them in experimenting with dirigible balloons, an offer which was accepted in 1907. Those were the years when aviation was beginning to be recognised as practicable. He became fascinated with the idea of the heavier-than-air machine, to which branch he decided to devote his entire energies. A few months later he met Wilbur Wright at Le Mons. After watching his flights and studying his experiments Horace Short obtained a contract to build the Wright biplane in England. This work was carried out at Shell Beach, Isle of Sheppey, where those of us who were already enthusiasts in those seemingly so distant days used to spend some of the happiest and most memorable hours of our lives watching the early pilots "hatch eggs," studying the weak points of such engines as were then available, and being fascinated by the fertile brain of Horace Short as he dealt with one knotty problem after another that arose in connection with the evolution of aircraft. Even then his love of the open sea made him appreciate to the full the possibilities of the seaplane. His first notable success, however, was with a land machine, the biplane he designed and built for Mr. (now Major) J. T. C. Moore-Brabazon winning the "Daily Mail's" £1,000 prize for the first circular flight of a mile by an all-British aeroplane. That was in November, 1909.

Thereafter, development was rapid. Together with his brothers, Horace Short moved the establishment to Eastchurch and there built the biplanes on which the first four officers appointed by the Admiralty to the Royal Flying Corps (Naval Wing) for flying duties were taught to become pilots.

In 1912 his seaplanes were realising dreams that Jules Verne himself might have dreamt. In that year Commander C. R. Samson, R.N., made the first flight from a battleship, H.M.S. "Africa."

Horace Short's famous folding wing seaplane, which made it possible to carry seaworthy aircraft on ships of moderate size, also to house the largest types of aircraft in sheds of reasonable dimensions, was produced in the following year. From that period onwards one development followed another with increasing rapidity, for he realised the value of the new weapon to the greatest naval power in the world in the event of war, and that event materialised with appalling suddenness, hence he did not spare himself. On Christmas Day, 1914, a raid was carried out on Cuxhaven by several Short seaplanes, while on another occasion Squadron Commander Seddon, R.N., flew from the Isle of Grain to Plymouth in quest of a lost submarine. Again a Short seaplane was the machine used by Flight Lieut. Rutland in the historic task that officer achieved during the greatest naval engagement in history, the Battle of Jutland. For obvious reasons one cannot give anything like a complete list of the notable parts played by Short aircraft in this war. Hence, one illustrates their further use merely by adding one example, namely, the dropping of flour on Kut during the time General Townsend was besieged with the gallant garrison there. Had something like six times the number of machines been available that fine leader need never have surrendered for lack of food supplies.

In any other country than this such a man as Horace Short would have found his name a household word, and his story would have been one of the most familiar among all classes of the community. But he ever shrunk from aught in the guise of publicity, so that even in aviation circles only a small percentage of enthusiasts knew anything about the man's personality. All who knew him not merely admired him enormously, they, besides, acquired a degree of affection for him beyond the ordinary. What the British Navy owes to him it is impossible adequately to state. The lapse of years will cause his work to emerge in true perspective. Then we may look for his name to figure as the foremost of our pioneer aircraft constructors. No better testimony of this can be offered than the unanimous decision of the British aircraft industry to raise a suitable memorial to him at the earliest opportunity. His colleagues realise, of course, that such a man would not consider the present to be such an opportunity, for if ever there was a man who understood this war in all its awful seriousness and who had an intelligent grasp of its mighty consequences to the destinies of the world, his name was Horace Short. When we shall have finished the war, and not before, would such a nature welcome the notion of a memory being perpetuated and a man's work being commemorated.

Horace Short was both a man of fertile, fresh and great ideas, and a master builder. Of him it could not be written that he "builded better than he knew," because he knew how to build the best possible and strove with his very might to make all associated with him attain to his ideal. "Short built" are words which, when they come from the mouth of a man in the Services, mean that which proves Horace Short succeeded in inspiring his fellow workers to achieve the highest standard attainable. In the workshop no man could be more justly severe in censure. His overseeing was always to ensure "safety first." And his work has placed the British seaplane industry in that relation to that of other nations which has long been occupied by our shipbuilding industry in its own kind. When he said "No" about a proposed construction not even the Admiralty would press the matter further. The man has not been born who could shift him from a fact, nor does the world hold the money that could have tempted him to depart from a conviction.

Happily, both the science has progressed to such a stage and our native aircraft industry has become sufficiently developed for us to be able to carry on, though robbed untimely of a brain so resourceful, so rarely practical and so original. Comparatively young in years, but old both in experience and in achievement of the first quality, Horace Short's name will ever be held in the highest regard by all Britons who cherish their country and value the type of leaders who, from generation to generation, have made this Empire what it is. The nation is the richer for his life and work.

H. M. B.

REVIEWS.

Aeroplane Design. By F. S. Barnwell. And **A Simple Explanation of Inherent Stability.** By W. H. Sayers. London: McBride, Nash and Co. 1917. 2s. 6d.

The first part of this little book is devoted to a common-sense exposition of the elements of aerodynamics, as applied to aeroplane design. The author very sensibly develops his subject by giving a brief outline of the designing methods used in fulfilling a certain specification. As, in practice, the specification is usually the starting point of aeroplane design, this method of treating the subject will be of more value to the student than a disquisition on "maximum-maximorum" efficiency.

It would be interesting to have further light thrown on the derivation of certain of the empirical formulæ, *e.g.*, the formula for rudder area, given on page 58:—

(A constant) × (rudder moment) = (area of side elevation) — (half the moment of side elevation) + (the area of aerofoils).

The dimensions of the constant must be somewhat peculiar in order to make the dimensions of each side of the equation consistent.

This section of the book more than fulfils the author's very modest claim set out in the penultimate paragraph of his conclusion, though it is a pity that the criteria of performance, power loading, aerofoil loading (as determined by the minimum speed), etc., are not more strongly emphasised.

With regard to the "Simple Explanation of Inherent Stability," one cannot do better than quote Mr. Sayers in his first paragraph:—

> "It is unfortunately . . . the case that many writers and students dealing with this question in simpler language than that of the mathematician, have been led astray by the too apparently obvious."

In this connection it is interesting to compare Mr. Barnwell on lateral stability (page 60, 61 and 62), with Mr. Sayers on lateral stability (page 82 and 83, figures on page 80). Mr. Barnwell, in giving the correct dynamic explanation of the stabilising effect produced by the dihedral angle, says:—

> ". . . Rotation about the longitudinal axis, or rolling, will *by itself* produce no change whatever upon the air reactions on the machine; that is to say, if an aeroplane rotate about an axis parallel to its flight path, *no other motion being present*, no force is created to counteract the rotation."

Mr. Sayers, on the contrary, demonstrates a static righting couple produced by the change in value of the vertical components of the aerofoil reactions (P_1 and P_2) when the aeroplane is tilted laterally. He conveniently omits, however, the horizontal components of these two reactions which produce an opposite couple.

The problem of stability, involving as it does three rotational and three translational motions, is exceedingly complex, and does not lend itself readily to simple explanation; and it is doubtful if the exclusion of dynamics makes for simplicity.

Mr. Sayers' loose treatment of relative motion, so frequently the subject of confused thought, renders his explanations difficult to follow, if not misleading.

"OMICRON."

Edward Teshmaker Busk. By "M.B." Glasgow. 1917. R. Maclebere and Co.

The record of a young and vigorous life, instinct with intellectual activities, ought to thrill us with enthusiasm. Such records often fail to do so because the writer usually seeks to gain approval for the hero by tuning him up to the conventional standard. Edward Busk's early life, written by his mother, shows none of these faults. It has but one defect, its brevity. Tragic the end of the story has to be, and to those who know the end, one's sympathy with the writer is indeed acute. The book is full of freshness and charm, the story of a youth who could not only think clearly and act with self-reliance, but whose co-workers esteemed as an exceptionally quick intelligence. He was one of those who remain original to the end, whether in work or play. His lot was cast in pleasant places and he amply justified his good fortune, though dying a martyr to his own thirst for knowledge at the very moment when his services would have been most of service.

Ballads of the Flying Corps. By G. R. Samways, R.F.C. London: McBride, Nash and Co. 1917. 2s. 6d.

These verses are rather of the earth than of the air, although there is a certain amount of breeziness about them. Mr. Samways is evidently an admirer of Kipling and of Adam Lindsay Gordon, but he has considerable power of versification.

RECENT ADDITIONS TO THE LIBRARY.

"Rasselas," including "A Dissertation on the Art of Flying." Dr. Samuel Johnson. 1818. The Chiswick Press, London.

"Erecting and Aligning Avro Aeroplanes." A. V. Roe. 1917. Manchester.

"The Aeroplane Speaks." Capt. H. Barber. 1917.

"Ballads of the Flying Corps." G. R. Samways. London: McBride, Nash and Co. 1917.

"The Flying Girl." Richard Marsh. London. 1916. Ward, Lock and Co.

"The Lad with Wings." Berta Ruck. 1917.

"The Motor, Marine and Aircraft Redbook." London. 1917. Technical Publishing Co.

"Small Factory Output and How to Speed it." G. H. Mansfield. London. 1916. McBride, Nash and Co.

"Meteorological Glossary." London. Meteorological Office. 1916.

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